PLANT ENGINEER'S MANUAL

COMPILED by
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Facts and Figures for the Plant Engineer

Compiled by

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Editor of INDUSTRIAL ENGINEERING

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PREFACE

Industry itself is responsible for the term *plant engineer*. It has adopted this term as a title for men performing certain functions, the functions of keeping plant equipment and buildings in such condition that production will never be interrupted by service failures.

It follows that plant engineering has to do largely with equipment other than production equipment. The machinery that actually turns out the product is designed by specialists for specific operations. The auxiliary equipment, however, although also designed by specialists, must serve a multiplicity of purposes and under all kinds of conditions.

On account of these differences the plant engineer must carry the burden of seeing that the selection of the auxiliary equipment is such that the application in his plant will be proper, efficient and economical. His is the realm of mechanical power drives, electrical drives, controls, distribution stations, and similar equipment.

Not only must the plant engineer select such equipment, he must install and maintain it. Hence he is sometimes called equipment engineer, maintenance engineer, just plain engineer, and by a variety of other titles—but they all refer to the functions of plant engineering.

His job almost invariably includes the installation and maintenance of production equipment. He maintains materials handling equipment and influences its selection. He is called upon to help select, and then maintain, a great array of plant necessities such as lighting equipment, alarm and fire protection systems, signal systems. He may have all the responsibility of plant housekeeping. Painting is one of his jobs. Keeping roofs and floors in condition is another. His services are constantly in demand, and he is expected to know something of everything.

Life is too brief for the plant engineer to learn everything in school or college. He must pursue his educa-

tion while he is on the job—he is never through learning. He has a really big job—trying, to be sure, and demanding knowledge and resourcefulness—but one to be proud of.

This manual is one of INDUSTRIAL ENGINEERING'S contributions toward his continuous education. It is a collection of some of the indispensable information presented from month to month in the editorial page of INDUSTRIAL ENGINEERING in its important job of telling the plant engineer what to do, how to do it, and what to do it with.

CONTENTS OF PLANT ENGINEER'S MANUAL

I

AROUND THE PLANT

PAGE

Systems 9

Safety 16

Handy Plant Kinks 21

II

MECHANICAL

Belts 43

Bearings 53

Lineshafts 65

Lubrication 83

Mechanical Power Transmission 88

III

ELECTRICAL

Batteries 123

Drying Out Coils 125

Electric Controls 127

Electric Testing 152

Heating and Ovens 170

Insulation 171

Lighting 177

Motor Repair 180

Motor Testing 184

Motor Winding 188

Welding 193

Wires 197

Index 203

I

AROUND THE PLANT

AROUND THE PLANT

SYSTEMS

Inspection System Forestalls Production Delays at Dennison Manufacturing Company

An inspection system should be a staff function organized to: (*a*) maintain quality of product and safe operation, (*b*) maintain continuous operation of manufacturing and service equipment, (*c*) reduce the cost of up-keep to a minimum.

At the Dennison Manufacturing Company plant at Framingham, Mass., the inspection is made by, or under the direction of, a staff department in the plant engineering division. From actual experience it is apparent that the benefits obtained are in direct proportion to the confidence in the inspection system and co-operation established in the minds of those in charge of operating the equipment in the plant.

In general, the inspection system is outlined in detail on fifty or more forms, covering all classes of equipment. These forms are not, at the present time, uniform in size or character, but an attempt is now being made to standardize them which will increase their value as a permanent record.

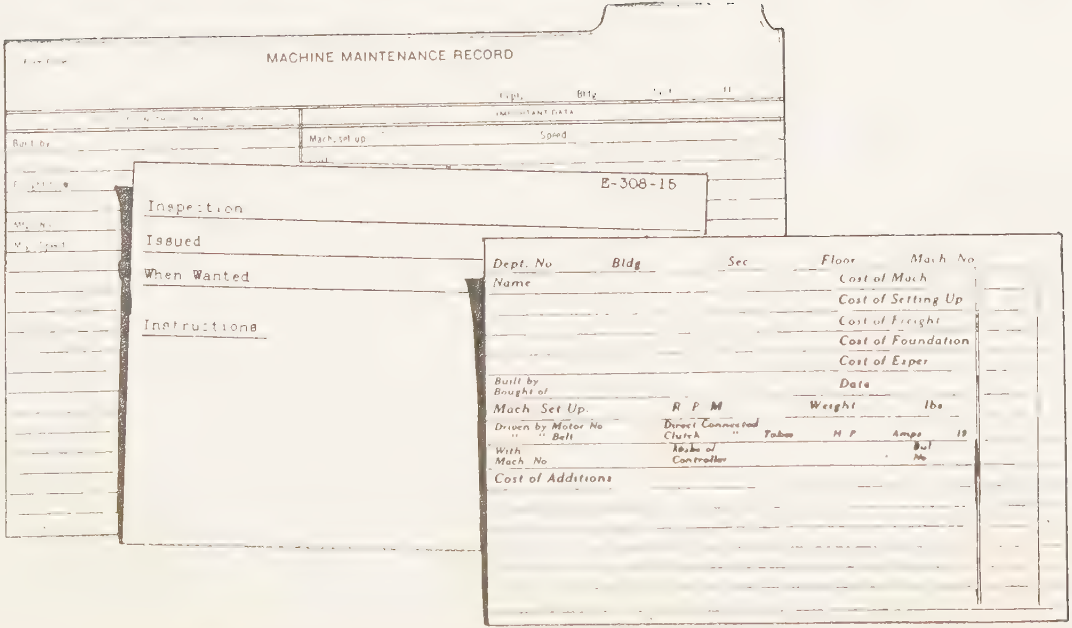
All inspections are made at definite intervals, and followed by means of a perpetual calendar. When the time arrives for an inspection to be made, an inspection card is removed from the file and put in its proper place to come out on the next inspection date.

1. (*a*) The inspection of power equipment and distribution is supplemented by the services of an outside inspector. Such a plan is particularly desirable when equipment for testing is not available and where technical experience of the local staff is not sufficient to detect the more obscure faults which may occur.

1. (*b*) Inspection of motors and control equipment is carried on by a supervised inspection, covering, at the same time, the cleaning, oiling and minor repairs. Electrical inspection also includes verification of record for machine speeds and tests of motors for overload and speed control.

1. (*c*) Mechanical power transmission is not a large problem in this plant. Only superficial records are kept of belting and inspection orders are performed by the belt repair department.

1. (*d*) Plant inspection includes the condition of buildings, stairways, structures, floor loads and all conditions which relate to fire prevention and safety



Machine maintenance, inspection and perpetual calendar inspection cards used by the Dennison Manufacturing Company to keep tab on the condition of their equipment.

to employees. Inspection of material handling systems are made to anticipate repair work, but also to direct the oiling and cleaning.

The most important inspection of service equipment is for elevators. Here we have weekly, monthly and quarterly inspections. The weekly inspection is made in conjunction with the elevator operator. The more complete monthly inspection covers conditions of ropes, elevator machine and safety equipment. The quarterly inspection is made by a representative of an elevator manufacturer in the presence of the department inspector and serves as a check upon the local inspection.

Heating equipment is inspected at the beginning of the heating season and the control of the heat, to provide proper temperatures in the manufacturing department, is directed by the inspection department.

Steam traps, reducing valves and compressed air systems are inspected monthly, and more frequent attention is given where necessary, to maintain at all times, proper working conditions in the manufacturing departments.

In this plant the machine inspection in producing departments is one of the most important branches of this work. Regular machine inspections include preventative repair work, improvements necessary to maintain quality, supervision of oiling and cleanliness.

The inspection department directs the engineering division regarding supply parts to be carried in anticipation of repair work.

2. It is the duty of the "Plant Engineer" to see that the work recommended by the inspection department is justified, and that the cost of the inspection system is comparable with the advantages to be gained.

3. In carrying on the work in the inspection department, use is made of the records which are kept for other purposes in the engineering division. For instance, the repair expense of each piece of equipment is added to a machine card together with the original cost and the cost of any additions or alterations. The inspection department refers to these cards when making their inspections and this information is a guide to them in recommending rebuilding or replacement. To follow the completion of inspection orders, the inspection department keeps a copy of the orders issued until the record is entered on the machine card.

4. The actual need of replacement does not always originate in the inspection department. More often, the request comes from the manufacturing department, or is brought about by a technical study of equipment to reduce costs. When excessive repair expense is shown on the machine card, the inspection department studies the machine to determine if the repairs can be reduced by re-designing the equipment, or by substituting different repair materials.

When an inspection department is first adopted the repair expense may for a year or more show a decided tendency to increase, but the experience in this plant has shown that after the first year the repair

expense in relation to total investment has been lower than it was previous to the inspection system. With the operation of such a system it is very easy to extend mechanical supervision to oiling and cleaning.

Plant Engineer,
Dennison Manufacturing Company,
Framingham, Mass.
HENRY F. SCOTT.

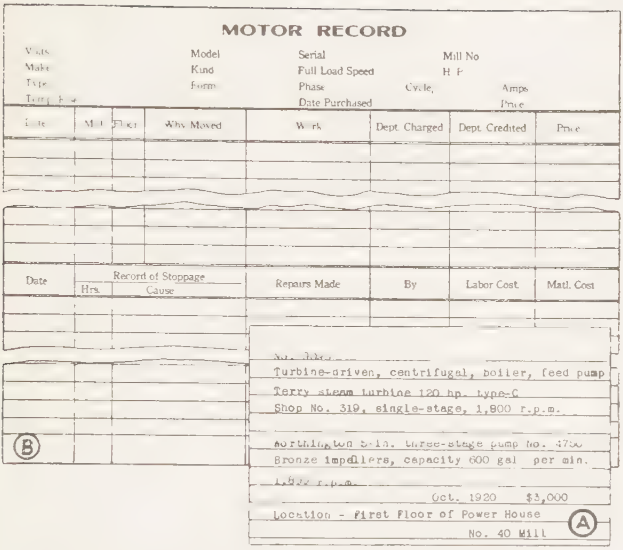
Handy System for Keeping Service Records of All Machines in the Plant

In every industrial plant of considerable size where there are many machines of various kinds, the task of keeping a service record of each machine's history, present location, and so on, is a difficult one. As a matter of fact, many plants do not keep such records, or if they do keep them, these fall far short of giving the information required. The following gives the details of a system used in a large textile plant where 15,000 machines including motors are in active use; yet the complete history of specifications, date of purchase, cost price, present and past locations are all available at a moment's notice. The value of such a system of records in case an inventory is desired of the plant equipment is not hard to realize.

Every machine and motor in the plant, whether old or new, is given a number. A brass plate about 7/8 in. wide and of the necessary length, stamped with black enamel figures, is fastened to some prominent part of the machine with escutcheon pins. The No. 44 special hardened drive pin, ¼ in. long, made by the Parker Supply Co. of Springfield, Mass., is excellent for this purpose. This pin has a steep thread cut on its surface and it is driven into the previously drilled hole, the threaded portion cuts a corresponding groove in the metal, so that the pin will not become loose. If plain escutcheon pins are used they are very likely to come out, allowing the number plates to fall off and the identity of the machine to be lost. If the machine or motor has a manufacturer's name-plate, the plant number plate should be placed adjacent to it.

A 3-in. by 5-in. white ruled card is used for entering the number of the machine, the name of the equipment, the name of the firm from which the machine was purchased, the manufacturer's name, the date of purchase, cost price, location of machine, and so on. If the machine has a shop or manufacturer's number, that also is entered on the card, since it is an important feature in ordering repair parts. In the accompanying illustration *A* shows a typical card used for a centrifugal, turbine-driven, boiler feed pump.

If a machine is broken up and scrapped the words "Broken Up" with the date are entered on the card. A blue card of the same size as the white one is then filled out with the same data that appeared on the original white card, the white card is taken from the active file and the blue card is put in its place. The white card is then placed in a separate file marked



Typical cards used for keeping, A, machine records, and B, motor records complete and up to date.

"Machines Broken Up." If a machine is sold to an outside party the same procedure is followed except that a salmon-colored card is used, and the white card is placed in a file marked "Machines Sold." If a machine is not sold or broken up but is simply taken out of active service and placed in storage, a manila-colored card is used and the white card is placed in a "Machines in Storage" file. If the machine is moved to another part of the plant, but is still kept in active use, then the new location is entered on the white card and the card still remains in its original file.

Thus at all times the active file will show first by the white cards the equipment in use, by the blue cards equipment discarded for all time, by the salmon-colored cards equipment sold and by the manila cards equipment in storage. On the other hand, the files "Machines Broken Up" and so on will show in respective groups the disposal of all equipment. In these latter files the white cards are also arranged alphabetically.

One complete set of these files with cards is kept in the office of the Mechanical Superintendent, one in the General Superintendent's office, and one in the Accounting Department where the inventories are made up. If a machine is moved, broken up, sold, or placed in storage, a special notification card to that effect is made out in the department where the machine is located, giving the details of the change; this card is sent to the Mechanical Superintendent's office. The necessary changes in the file are made there by the

file clerk, and he advises the clerks in the other departments where there are similar files so that they also can make the changes. The files, therefore, show at all times the complete history of all equipment from the time the system was begun. This information will be found invaluable in many ways, but particularly when taking inventory.

In *B* of the illustration is shown a card used in the same plant for keeping a complete record of the electric motors. In a mill where there are several thousand motors, if some system is not used it is impossible to keep track of the repairs and troubles that arise. Such a motor record as is contained on this card will be of great value in showing up weak points in the manufacture, design, or maintenance of the equipment. This card measures 8½ in by 11 in. At the top of the card is entered the same data as is on the corresponding 3-in. by 5-in. card previously described. In addition, the card shows the various locations where the motor has been, the departments to which it is charged or credited, and so on. On the lower half of the card is kept a record of the failures and repairs, by whom made and at what cost. Here again we have the complete life history of each motor at a glance. One file of these cards is located in the office of the Electrical Engineer and another in the office of the Mechanical Superintendent.

In the case of the 3-in. by 5-in. cards first mentioned, often the head of a department will wish to have a set of cards that list the machinery in his department. These two systems are very flexible, and can be altered in detail to meet any special conditions that may arise. Once installed they are easily kept up to date and will be found to be in constant use for reference.

Lawrence, Mass. A. J. CALHOUN.

Method of Checking Progress of Work on Large Installations

When making large electrical installations it is very desirable to have some method of checking the progress of the work at all times in a simple manner.

An easy method of doing this is to provide the mechanics with sheets of transparent paper of the same size as the sketches or prints. The transparent paper should then be tacked over the print on a suitable board.

As the various pieces of apparatus are installed, their outlines can be traced on the transparent paper directly from the print. Also, as each connection is made, it should be traced on the paper. In this way a continuous check is made which not only shows the progress of the work, but the check is a great aid to the installers in following through the wiring on a complicated piece of work such as a large control board.

J. B. RAKOSKE.

Schenectady, N. Y.

Routine for Lubrication and Inspection of Cranes

In one of the largest steel plants, where the crane inspector is not a member of the crane repair gang, a weekly detailed inspection is made, usually on Friday, of all parts of hot metal and ladle cranes, and elevators. As the inspector goes along, he makes notes of anything he finds which needs attention immediately or in the near future. He carries a hammer and a short bar with which he tests the tightness of bolts and caps and checks up the amount of play in the bearings. His inspection covers every electrical and mechanical part of the cranes.

The inspector's report is typewritten; one copy is made for file, one for the superintendent of the electrical department, one for the general foreman, and one for each section foreman. If the inspector finds that any part needs immediate repair, this is reported to the foreman in charge of the works at the place where the crane is located. This report which is made by word of mouth, is noted without delay on the inspection report. Cranes other than those mentioned above are inspected by the cranemen who, while oiling their cranes, report any trouble or irregularities to their foreman.

In addition to the reports on the hot metal, ladle and heavy roll cranes, a chain and cable report is made up and carried forward each month showing the date of the last change and the number of tons or days to run until the next change. The tonnage or time allowance, as the case may be, is determined by years of experience. The ropes or chains are removed regardless of their condition at the expiration of the period. The 1⅛-in. chains on old ladle cranes are minutely inspected, and if repairs are necessary, they are sent to the factory which produced them to have worn links replaced with new ones.

The entire chain is then annealed and proof-tested to the original strain, and a test certificate is sent back with the chain. The chain is then held in storage for another run. Smaller chains when removed are not again used on the cranes from which they were taken. The good ends of such chains are cut off and used for slings, and the worn-out parts are scrapped.

Wire ropes that are removed from hot metal and roll cranes are never again used on these cranes. The worn or defective portions are removed from the ends, and then they are used on yard cranes where shorter lengths are employed. Ropes and chains are inspected each week by the crane inspector and their conditions noted because it has been necessary in a few cases to remove ropes before the allotted tonnage or time had been reached.

These cases were due to defects in the ropes or because of their being burned. This periodic inspection, it is believed, has prevented sudden failure and possibly damage or serious tie-up.

Lubrication of cranes is handled by the crane operators, except in extremely heavy tonnage periods when there is an oiler for the strippers and pit furnace cranes. Some of the cranes are equipped with a force-feed, grease gun system, but most of them have hand-oiled bearings with some hand-screw feed grease cups. In some parts of the works where the crane service is continuous, the operating departments provide a stated period of 20 to 30 min. for lubricating the cranes. However, they are usually lubricated when the operator sees an opportunity, which may come any time during the day. When the time for oiling is not fixed, there is frequently trouble with operating foremen who do not like to have the cranes stopped for lubrication.

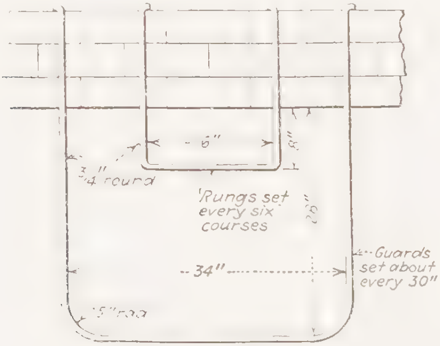
D. W. BLAKESLEE.

Pittsburgh, Pa.

SAFETY

Construction of Rungs and Safety Ring for Ladder on Brick Wall

It is common practice to erect a steel ladder on the outside of a brick wall where the height is considerable, and to put safety rings outside the steps so that a man may rest or be guarded against falling backwards in case he should slip. The strain of climbing



Steel rungs in ladder and safety guards which were placed on 40-ft. brick wall.

It is not necessary for the ends of the steel sections to extend entirely through the brick wall, but they should be set in at least through the second tier of brick.

a vertical wall is considerable and even if a man is not carrying a load he may wish to rest occasionally. Where these walls are built by specialists they usually have stock parts for constructing the ladders and rings. However, where the local Building or Maintenance

Department has this work to do, such parts are not always available.

The accompanying drawing shows clearly the construction of a safety ladder that was erected on the outside of a 40-ft. wall of a building into which refuse was to be exhausted. This inexpensive construction fortunately represents good practice, also.

Both the rungs and the safety rings are made from ¾-in. round stock. These pieces were cut off cold on the anvil and the ends were given a blow with a heavy hammer to put a bend at the end, as shown. This bend was of no definite amount but merely to add to the burr from the cutting off so as to make a knob that could not be pulled through the brick work.

The bend was made on a Wallace bender. The rungs or steps were given a bend of short radius. The safety rings were given a bend with a 5-in. radius, which was easy to make and which permits of ample climbing clearance. The round corners also improve the appearance. Some stack safeties are made with round or hoop rings, but these seem to restrict climbing space and interfere with a man carrying anything strapped on his back. However, it is safer to pull any tools or materials up with a rope than to try to carry them up.

When this structure was being built up, the steel parts were laid in between the joints in the brick as the courses were laid. The rungs were placed between every six courses of brick, which were approximately 15 in. apart, an easy climbing distance. The safety rings were placed 30 in. apart because it is not necessary to have them as close as the rungs.

In laying the bricks, care was taken to see that each steel bar was pressed into a bed of cement mortar and that the joint was well filled around the steel. This insured a firm grip between the steel parts, to resist any tendency to pull them directly outward. In addition, the crook at the inner end of each leg gives added security against any tendency of the rungs or guards to loosen or pull out.

DONALD A. HAMPSON.

Plant Superintendent.
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Safety Rules for the Guidance of Crane Operators

At one of the large iron and steel works, considerable importance is attached to certain rules governing the duties of the operators of cranes. In order that their operators may be at all times familiar with these rules, an enameled plate of these regulations, which reads as follows, is hung in each crane cage:

(1) No one but a regularly authorized operator is allowed to use this crane.

(2) You must thoroughly inspect your crane at the beginning of each turn and see that all bolts and nuts

are tight, and that all chains and cables are in safe condition.

(3) You are forbidden to operate your crane when it is not in a safe condition; report immediately to your foreman on discovering any defects.

(4) Do not operate your cranes when anyone is working on your crane runway or any runway adjacent thereto, unless authorized to do so by the foreman in charge of crane repairs.

(5) Do not move without a signal from the proper man. See that the trolley is directly over the load, to prevent swinging. Be sure that every one is "Clear"; ring gong; start slowly.

(6) Do not carry load over men on the ground; use gong. Watch your empty hooks.

(7) You will be discharged if you allow anyone to ride on the load or on crane hooks.

(8) All safety devices must be maintained; operators showing a disregard for safety will be discharged. Keep your crane clean. Do not allow loose material to remain on it or on the runways.

(9) Do not leave your crane cab without first pulling out the main switch; when going up on top of the crane for any reason, put a red flag in open switch.

(10) No repairman shall make any repairs without first locking the main switch open and hanging a danger signal on the crane directly underneath work being done.

In an extreme case when the crane has to make a lift before repairs are finished, the craneman is thoroughly instructed by the foreman in charge of the shop or by the electrician. The operator will understand that each move to be made will be upon signal from the one who has just given him his instructions. The foreman or electrician will also see that each man on the job is in a safe place before signaling the craneman to move. In this case the lock on the switch is temporarly removed by one of the repairmen on the job and replaced by him when the movement is completed. Strict adherence to these rules has a tendency to lower accidents because definite responsibility is fixed for the movement of the cranes. The crane operator by virtue of these rules has certain authority in so far as the operation of the crane is concerned. The completion of any lift is dependent upon the one giving the initial instructions.

D. W. BLAKESLEE.

Electrical Engineer,
Jones & Laughlin Corp.,
Pittsburgh, Pa.

First Aid to Eye Injuries

There are three cardinal principles of first aid after eye injuries. The first of these is cleanliness; next, prompt rest for the eye; and, third, medical care directed by a competent physician, preferably an oculist. These principles apply even if the injury is slight, and they are imperative with serious eye injuries.

In removing dirt, it is a common custom to lift the upper lid and to push the lower lid with its lashes over the eyeball well up under the upper lid and then to draw down the upper lid. This procedure often enables the lashes of the lower lid to drag out of the eye a bit of dirt or rough material that may be causing great annoyance. The method, however, has all the possibilities of introducing an equally annoying amount of dirt and, what is worse, of sometimes introducing directly from the soiled lashes germs that may find an ideal place to grow in the freshly scratched tissues from which the dirt was removed.

Cleanliness, then, is the first thing to think of. Refrain from pushing the lashes under the lids until the lashes have been washed and be sure that the fingers that are going to handle the lashes and lids are also thoroughly washed. Make certain that the medicine dropper or eye-cup that may be used has been thoroughly cleansed.

A rough bit of dirt blown into the eye may be comparatively harmless if removed quickly and carefully, but with rough manipulation through rubbing of the lids, the dirt may actually be driven into the tissues of the eye or may cause numerous scratches on the lining of the lids or of the conjunctiva covering the eye-ball. Broken surfaces are thus exposed to all sorts of infection, and abundant opportunity is given for germs to be carried into the eye tissue with the original particle of dirt.

Make no attempt to remove particles of dirt from the eye until the hands and lashes have been thoroughly cleansed. Next, take a little twist of the cleanest of absorbent cotton, either twisted tight upon its own fibers with a little tufted tailpiece, or twisted about a matchstick with a little tuft extending from the end. Separate the lids and note the location of the thing to be removed. With the prepared cotton it is usually very safe to gently drag the tailpiece over the thing to be removed. The cotton drags it out. If no cotton is available and the dirt is on the inside of the upper lid, then, after cleansing the lashes, the under lid may be pushed up under the upper lid, which should then be drawn down quickly, affording an opportunity to drag out the dirt with the lashes of the lower lid.

The corner of a perfectly clean handkerchief fresh from the laundry may be used like this cotton twist in removing dirt.

Many eyes are infected and some lost because of the introduction of germs from dirty hands, dirty handkerchiefs, dirty lashes or dirty materials used in attempting to do the kind thing for the individual suffering with dirt in the eye.

If much scratching occurred during removal of dirt or if dirt has been in the eye for a considerable length of time, great comfort may be had by gently placing a piece of soft linen that has been boiled and wet with cold water, over the eye and then very lightly bandaging the eye. This places the eye at rest, makes

easier lifting lids from eyeball by the tears and favors start of the healing process. This is a good procedure to follow until such time as medical advice and treatment may be secured.

In graver injuries, where flying particles may have been driven into the eye tissues and injured the outer covering of the eyeball, it is wiser immediately to cleanse the outer surface of the eye, lashes and lids, place a wet dressing over the eye with a light bandage and secure forthwith medical opinion as to the best method of procedure.

The dirty habits, such as removal of things from the eye by utilizing a matchstick that has been carried in the smoker's pocket for a long while, have been largely discarded. In modern factories and mills nowadays instruction is given to employees in first aid, and, at convenient points throughout the plant, first-aid equipment stations are maintained with clean, sterilized materials such as are used in hospital operating rooms always available.

By closing the eyelids until a good flow of tears accumulates under them and then blowing the nostril hard on the side toward the eye in which the dirt is located, one may often wash the irritating bit of dirt down the nose.

It sometimes happens that an acid burn of the eye is sustained. It is safe immediately to wash the acid-burned area with an alkaline solution made by adding half a teaspoonful of ordinary baking soda (bicarbonate of soda) to half a glass of water, or, in the absence of water, one may put a little of the dry powder into the eye. Introduction of the powder may not be quite comfortable, but it will retard the deep burn and in most instances will be soothing.

Printed or typewritten instructions may be available, giving suggestions as to what may be done until a doctor can be secured. In all such first-aid efforts stick to the cardinal principles of cleanliness, doing no hurt and placing the eye at rest.

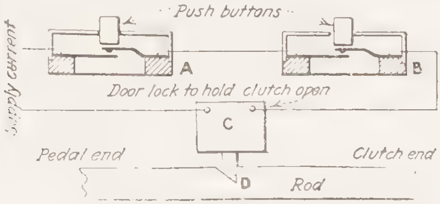
B. FRANKLIN ROYER, M.D.
Medical Director,
National Committee for the Prevention of Blindness.

Safety Lock on Pedal-Operated Machine

Some time ago I was asked to devise some sort of positive method for preventing operators of punch presses from getting their fingers caught under the dies. On these presses the operation of the die is controlled by a foot pedal. In one particular plant where I was engaged various mechanical devices had been tried out on the presses, but none of them proved satisfactory. So I built an electric device for releasing the foot pedal at the proper time of the machine.

The accompanying diagram shows how the clutch of a punch press can be held open until the operator's hands are clear of the die and the press. Buttons *A* and *B* should be placed one on each side of the machine

so that it will be absolutely necessary for both hands of the operator to be clear of the work on the press before the machine can be made to operate. When both *A* and *B* are pushed, an electric circuit is completed



The clutch rod is held by the catch at D until the lock, C, has been released by pushing the two buttons, A and B.

through the door lock *C*. When the door lock is energized, the catch at *D* is released, thus allowing the rod, which engages the clutch, to be operated by the foot pedal.

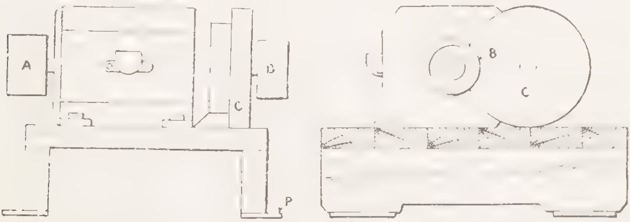
CHAS. A. PETERSON.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

HANDY PLANT KINKS

Portable Motor Unit for Emergency Service

In a very large plant where each machine is driven by an individual motor, the old method of "hustle and excitement" whenever a motor gave trouble has been eliminated by employing a portable motor unit, which can be hooked up in an hour's time. Under the present arrangement, the portable unit is always ready to move the instant a call comes into the repair shop.



The motor is mounted on skids and provision made as shown for obtaining any desired speed.

It consists primarily of a 15-hp. motor mounted on a skid of heavy construction, which can be moved by the ordinary lifting trucks employed for process work. Thus the motor can be shifted to the point of trouble in a very short time by any of the trucks that happen to be near by.

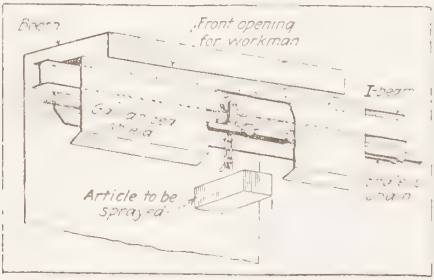
The unit is constructed to provide a wide variety of belt speeds. A pulley, *A*, is attached to one end of a special back gear shaft, *C*, and another pulley, *B*, is mounted on the rotor shaft. With this arrangement, and by changing the size of pulleys used at *A* or *B*, a wide range of speeds is available for driving any machine in the factory at its normal capacity.

Protecting Chain Conveyor From Paint in Spray Booth

In automobile and other plants where work to be spray painted in booths is carried past the operator on a chain conveyor, some method must be used to protect the conveying equipment, otherwise it will collect such a coating of paint as to interfere with its operation. The protection given in one automobile plant is shown in the accompanying sketch.

In this plant the pieces to be spray painted are carried through spray booths about 5 ft. square on trolleys supported from an I-beam and connected and operated by an endless conveyor chain. The piece is hooked to this trolley. Before the sheet-metal shield was installed as shown it was necessary to clean the chain frequently, which was an expensive operation.

The shield extends beyond the booth at each end and fits rather closely down over both sides of the I-beams and trolley and extends below the hook which supports the part to be painted. This keeps practically all the



Sheet-metal shield keeps paint from conveyor chain in spray booth.

paint except some fine spray from the trolley. The shield is easily removed for cleaning or to get at the chain or trolley.

G. R. Wilson.

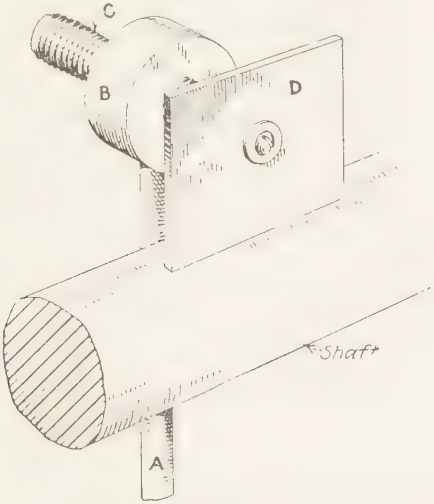
Flint, Mich.

Scraper for Cleaning Oil and Dust from Shafts

Accumulations of dust and grease often make it necessary to scrape lineshafts from time to time in certain types of plants. A novel scraper for this pur-

pose is shown in the accompanying drawing. This scraper is so made that it can be adjusted to suit shafts of various diameters. The eight scraping edges can be used a long time between sharpenings. The edge in use lines up square and lies flat on the shaft even though the handle is held out of vertical.

The handle *A* is of a length which enables it to be held from the floor. The handle is threaded at one end to fit into the collar *B* which is tapped in the center to take the scraper-holding-screw *C*. The scraper *D* is



Easily constructed device for scraping moving shafts.

Where accumulations of dust and oil on a shaft are undesirable, a scraper, such as this, handled from the floor, will quickly clean the moving shaft without danger to the operator. The scraper is adjustable to shafts of different diameters by turning *C* in or out of the collar *B*. The scraper can be set to the proper shaft diameter by measurement before placing on the shaft.

held in place by a screw and washer in the end of *C*. To operate this device the screw *C* is turned in or out of the collar *B* until the scraper *D* extends just past the center of the shaft to be cleaned, as shown. The operator stands on the off side of the shaft so that the rotation of the shaft is toward the scraping edge and pulls down slightly on the handle as he walks along the length of the shaft. If it would be objectionable for the scrapings to fall on the floor or machinery a basket arrangement could be placed on the handle *A* to catch the scrapings as they fall.

Although the scraper is hardened it does not cut into the shaft while cleaning it. However, merely scraping

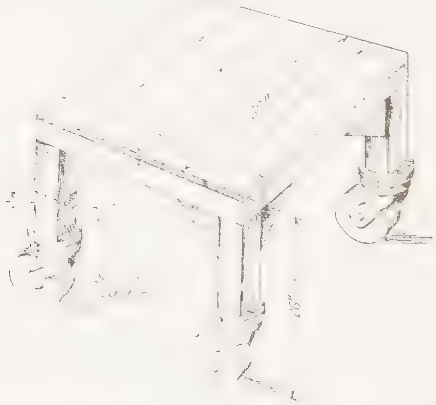
off the dirt soon tends to round the edge and the value of the eight scraping edges will be apparent. It is only necessary to remove the small screw and washer which holds the scraper *D* and turn the scraper over to get the second four edges. The edges are ground flat, as on a wood scraper, and a pull on the handle *A* brings the blade parallel and flat on the moving shaft.

Hamilton, Ontario, Can. H. MOORE.

Bench Truck for Transporting or Repairing Motors

A factory that is motor driven throughout has made the bench truck shown in the accompanying illustration, to transport the motors about as needed and for use as a temporary work bench. The plant has nearly a hundred a. c. motors of 2½- to 15-hp. rating in use and some spares.

Sometimes the work to be done consists of nothing more than putting in a duplicate bearing or cleaning out a dirty oil well, but the location of the drive is such that the work can be better done with the motor up where there is sufficient light and working space. It has been found that time is saved by loosening the four bolts holding the motor, disconnecting the coupling,



This bench truck is used for transporting or for supporting motors while making repairs.

and getting the motor in a convenient position, rather than by attempting to do the work in a dark and limited space. Also, when the motor is up where it can be examined carefully, it can be cleaned more easily and worn insulation, or other defects which would be likely to cause trouble later, are often found, although they may not have been noticed on the preliminary examination in the darker or more inconvenient location.

In addition, this truck is used to transport the motor when it has to go to the shop for more extensive repairs. An advantage here is that the truck belongs to the maintenance department and so can be used without interfering with production work. The truck is substantially constructed and has No. 190-L Payson swivel casters under it, which, combined with its relatively small size, enables it to be pushed around easily and into places where other trucking or loading equipment would not go. When in the shop the motor may be repaired while on the truck, if no other motor is down, and its size and height lend themselves to convenient working.

The factory's woodworking department turned out this truck. The legs and rails are made of maple and a 1-in. maple floor is laid on top. Carriage bolts (not shown) were placed diagonally at the corners and braces added for further stiffness. Use has demonstrated that the truck was built for rough service and it has more than earned its cost.

Plant Superintendent.
Morgans & Wilcox Mfg. Co.
Middletown, N. Y.

DONALD A. HAMPSON.

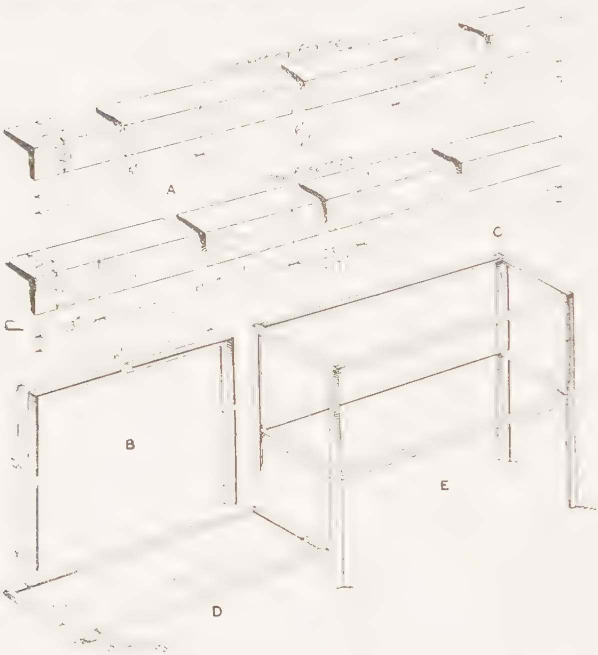
Handy Shelves for Shop Purposes

The fact that it is easy to nail a few boards together and pass them off as a shelf or rack probably accounts for most attempts at economy in the shop. If the matter of shelves or racks has been neglected or their purchase in the open market disapproved, a very cheap and durable shelf can be easily constructed in a short time. The material needed consists of angle iron and sheet iron, with some bolts and nuts, and the necessary tools.

In laying out the shelf, first determine the length and height desired. If the height is assumed as 5 ft. and the length 6 ft., it would be logical to order angle iron 16 ft. long to avoid cutting. I have found that angle iron 1½ in. wide may be used for most purposes. On a 16-ft. length as shown at *A* in the illustration, measure off 5 ft. from each end and mark with a center punch. With this mark as a center line to the edge of the angle iron, cut out a 45-deg. wedge from each side of the mark. When these notches are cut in one side of the angle iron, it can be bent to shape the frame for the shelf, as shown at *B*. If the cuts in the angle iron have been made properly, they will fit when bent to shape and then may be welded together for strength. Each section of shelf will require two of these angle-iron units cut to exactly the same length—one for the front, and the other for the rear section.

On a unit 5 ft. high and 24 in. deep, I have found two shelves practicable for most purposes. The frame *C* for shelf surface is laid out in the same manner as the supporting frame, and after preparation it is bent to shape as at *D*, with holes already drilled in the angle iron for the bolts. The assembly of the unit *E* follows,

in which the front and rear supports are then bolted to angle-iron spacers of the same size and so arranged that the supporting spacer is used to form a natural



A simple method of fabricating angle-iron shelf units.

The supporting members of the frame and the shelf surface are laid out according to the over-all dimensions, and then shaped and assembled as a unit.

shelf support. The shelf may consist of an ordinary piece of sheet iron, but where heavy materials must be supported, ¼-in. steel with a center brace is recommended.

E. J. MORRISSEY.

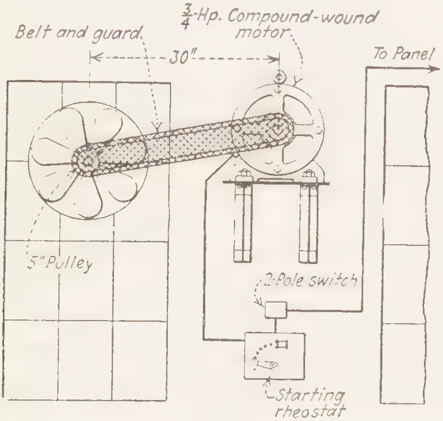
Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Changing Method of Driving Exhaust Fan Solved Motor Trouble

Frequently a baffling problem will cause the engineer of a modern industrial plant annoyance of the most exasperating nature; the more illusive the cause, the more trying it is on the nerves and patience of the engineer, as exemplified by the following experience. The Inspector for the State Department of Labor

ordered that an exhaust fan be installed in the lacquer spraying room of an industrial establishment. Although the lacquering was carried on under a hood equipped with an exhaust fan, a considerable amount of fusel oil fumes escaped into the room. The inspector held this to be detrimental to the health of the girls employed in the room, and so ordered additional ventilating facilities. Accordingly, a 36-in. exhaust fan, which was driven by a direct-connected, ¾-hp., 250-volt, series-wound, d.c. motor was installed in the upper half of the windows.

The installation functioned fairly satisfactorily for a while, until one day without apparent cause the armature burned out. The inspector happened to call at the plant while the fan was inoperative and ordered that the fan be kept running all of the time, without any excuses. Consequently, a spare armature was purchased and installed, but in a very short time the second armature burned out.



The belt is thrown off automatically and saves the motor when a high wind reverses the direction of the fan.

Formerly a direct-connected, series-wound, d.c. motor was mounted in the window, but strong gusts of wind reversed the direction of rotation and burned out the motor. By using a compound-wound, d.c. motor mounted on the platform and connected by a belt the motor is saved because the belt serves as a safety link and is thrown off by an overload.

A considerable amount of new construction work was going on in the plant, and the plant engineer had left the maintenance entirely to the foreman of the maintenance gang with instructions to bring only matters of real importance to his personal attention. Consequently, the maintenance foreman secured three spare armatures and replaced and rewound them as fast as they burned out, although he had difficulty

in keeping up the pace. Finally, all four armatures were in the repair shop at one time.

The superintendent of the lacquering department was annoyed because the fan was frequently inoperative, also the inspector threatened criminal prosecution, and called the attention of the plant engineer to the difficulty. An immediate investigation was undertaken. Load tests, which weie taken, seemed to indicate that the capacity of the motor was ample. A recording ammeter kept in the circuit for several weeks indicated that the load did not fluctuate appreciably and the difficulty appeared shrouded in mystery.

The engineer decided to watch the installation closely and visited the room several times a day for several weeks without results. At last his patience was rewarded. One day he observed the fan slowing down without any apparent reason, finally coming to a standstill, then actually reversing itself and driving the motor as a generator.

The fan was installed in a window on the sixth floor facing west and overlooking a bay. A high velocity west wind striking the fan blades would convert it into a wind turbine and drive the motor in the reverse direction as a generator across the 250-volt line, thus burning out the armature.

The installation was then modified as follows: The motor was disconnected from the fan and a 5-in. pulley installed in its place. A ¾-hp., compound-wound motor with about 25 per cent compound field, was mounted on a wall bracket about 30 in. from the fan and belted to the fan pulley. The modification proved very satisfactory. When a strong gust of wind would strike the blades and attempt to reverse their direction of rotation the fan belt would begin to slip and in the case of a very strong wind would be thrown off. In this way the belt served as a safety link which protected the motor against the heavy overload of the sudden gust and the consequent reversal which burned out the motor. As the belt was not thrown off frequently, it was not very annoying, and the belt was replaced easily. Although individual, direct-connected motor drives have advantages in many installations, there are many cases where a safety link is necessary between the motor and its load, as in this instance.

The installation of an exhaust blower leading to the roof and terminating in a revolving or other type of roof ventilator perhaps would have been a more satisfactory solution, but in this case it was objected to for several reasons.

E. OGUR.

Electrical Engineer,
Ampere, N. J.

One Way to Obtain Constant Spray Density

Maintaining a spray of constant density is a difficult problem. The greatest trouble is from clogging of the

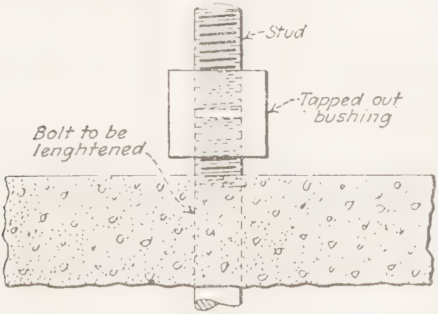
nozzle. Another source of trouble is due to changes in the density of the liquid, particularly with a lowering of temperature. Also, these troubles increase with the fineness of the spray required.

In one plant a spray as fine as the finest mist was required. The operating department had about given up the problem because it could not be sure of maintaining a spray of constant fineness; variation in density would have been fatal to the product.

The Master Mechanic finally evolved a plan that eliminated the nozzle and gave the fineness of mist wanted. This plan consisted of directing a high-pressure stream against a metal plate. In place of the nozzle the liquid was discharged from the open end of a small pipe. Of course, the liquid spattered and most of it ran down and off the plate, but this was collected and pumped back against the plate. However, above this spattering a constant mist arose that was finer than anything that had been produced before. The necessary arrangements were made to have the material to be treated exposed in this mist, and the most important troubles of the operation were over.

Bushing Method of Lengthening Anchor Bolts

Not long ago it was necessary for us to raise a machine several inches above its original position due to changes made in the gearing. We were at a loss for a while to know just how we could use the same foundation bolts, which were too short after the machine had been raised. After considering putting in new bolts, it was decided to make a bushing connection as shown in the illustration.



The old foundation bolts were lengthened by screwing steel bushings over them and then screwing stud bolts into the bushings.

We tapped steel bushings to the size of the bolts and screwed them down halfway on the original foundation bolts. Stud bolts were then made to correspond to the difference in length and these were screwed into the

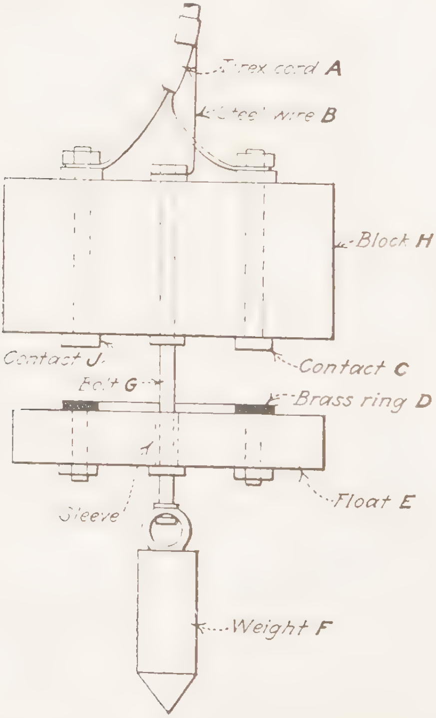
bushings, making the original foundation bolts the required length. The machine was set on the new foundation and put into service immediately. Considerable time was saved with this method, and we feel certain that it is a first-class job.

R. M. THOMAS.

Denver, Colo.

Portable Gage for Determining Depth of Water in Wells

In order to operate efficiently the condensers in our plant, it is necessary to know the water level in the various wells that supply water to the condensers. So far, we have employed successfully only one method of determining the water level in these wells.



This diagram shows the construction of the water-level gage.

This method involves the use of a float equipped with suitable contacts, which is lowered into a well-casing until an alarm bell rings. The ringing of the bell indicates that the device has been lowered to the water level.

Referring to the diagram the body of the device that is lowered into the casing is made in two parts, *H*, and *E*. The float *E*, is guided by a bolt, *G*, so that when the device is lowered to the water level, the water raises the float until the brass ring, *D*, short-circuits the contacts *C* and *J*. When these contacts are short-circuited, current flows through the Tirex cord, *A*, to the signal circuit. In order to keep the device in an upright position a weight, *F*, is hung on the lower end of the bolt, *G*.

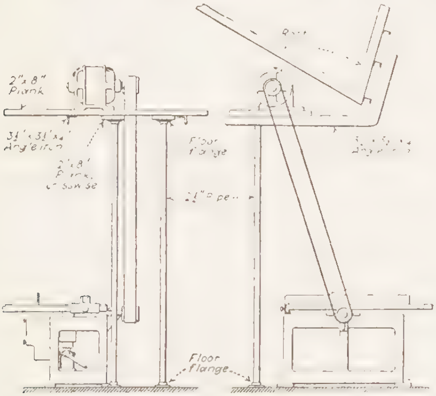
As the steel suspension wire, *B*, is graduated in feet and inches, the depth of the water level from the top of the casing can be read directly when the bell rings.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

CHAS. A. PETERSON.

Supporting Motor Overhead in Saw-Tooth Construction

Every industrial operating man has been confronted with the problem of mounting motors, countershafts, or other equipment overhead where there was practically



Method used to mount motor in saw-tooth roof.
The motor is mounted on a platform built of planks attached to heavy angle irons which are bolted to the roof. This platform is held up by upright pipes which in turn are held in place by floor flanges screwed to the platform and the floor.

nothing to which they might be attached. Such was the problem confronted in a medium-sized mid-western factory and the solution may be of interest to others, who are called upon to meet similar difficulties.

This plant was of saw-tooth roof construction, of light design, and not intended for supporting loads from the ceiling. When the plant was built, it was expected that the few machines necessary would have individual motors, either built-in or mounted directly

on the machine. The product handled was large in bulk but light in weight, so that it was not necessary to use overhead hoists or conveyors. The arrangement of each machine was carefully planned to give ample aisles and storage space for handling the product to and from the machines during the process.

The layout adopted, however, brought two of the woodworking machines under a sloping section of the ceiling, with nothing directly overhead on which to mount the motor. These two machines had been brought from the old plant and were of a type which could not easily be adapted to support the motor. Because of shavings and dust, it was not desired to place the motors on the floor, and a special mounting or platform built up from the floor would not only occupy needed floor space but would be in the way.

It was finally decided to make a special overhead platform for each motor, which was attached to the ceiling but supported from the floor. Accordingly, two pieces of 3½ x 3½ x ¼-in. angle irons about 6 ft. long were bent, as shown in the accompanying diagram, to conform to the slope of the roof and bolted to the steel structure in such a manner as to leave the two other ends extend out over the machine. Two 2 x 8-in. planks, about 3 ft. long, were bolted to these outer ends of the angle iron to form a platform for the motor.

Each platform was supported by two pieces of 2½-in. pipe attached to the floor. These pipes were threaded at each end and screwed into floor flanges, which were fastened by woodscrews to the floor and to short pieces of 2 x 8-in. planks mounted crosswise underneath the platform. One of these crosspieces and the pipe was placed directly under the motor and as near to the pulley end as possible, where it would support the most load.

This mounting, which placed the motor about 3 ft. away from the valley in the saw-tooth roof, was very substantial and practically free from vibration. The pipe supported the entire weight of the motor and platform, which in turn was tied to the ceiling from the side by the angle irons to prevent side motion. The planks in the platform were notched to let the belt pass through. The same method of construction could be used to support a countershaft, provided the side pull of the driving belt was not too great.

E. G. H.

Chicago, Ill.

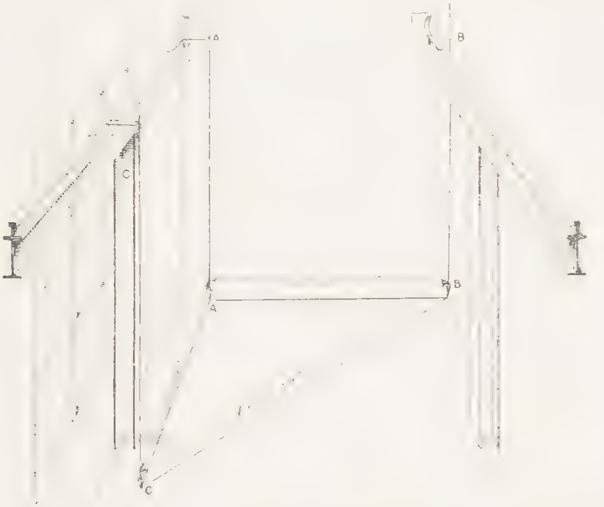
Checking Alignment of Bridge on Traveling Crane

To permit smooth operation, the track wheels on the bridge of a traveling crane and, in particular, the driving track wheels, must sit squarely with the rails. If the wheels are out of line with the rails, excessive binding will occur at the wheel flanges which will cause undue wear and may result in breakage of the wheels.

To maintain proper alignment, the drive wheels must

be of the same diameter. One-eighth inch difference in diameter of two wheels driven from a common shaft will cause one side of the crane to advance more than ⅜ in. for each revolution of the drive wheels. Considering a 2-ft. wheel, this means an advance of 6¼ in. in 100 ft. of travel. In other words, with this difference in diameter between two wheels, one side of the crane will travel one-half of one per cent further than the other.

The diameter of all driving wheels on cranes should be frequently checked. On account of the limited room for measuring this diameter, it will usually be found



For correct alignment, a line connecting the end bumpers should be at right angles to the rails.

By means of carpenters' squares and plumb bobs the span width AB is laid out on the floor, as shown at A_1 and B_1. Likewise, a distance equal to the span width is laid out on the rails at A to C, or as shown on the floor between A_1 and C_1. For the angle at A_1 to be a right angle the distance between C_1 and B_1 must be equal to the span width times the constant 1.4142.

most convenient to measure the circumference of the wheel by putting a steel tape around it. The circumferences of the wheels may thereby be directly compared. This is really more accurate than comparing the diameters of the different wheels.

Drive wheels found to have slightly different diameters must be replaced. We always match up our drive wheels in pairs, and consequently install them in pairs. Also, all new wheels are purchased in pairs. All wheels removed are checked for actual diameter, flat spots, and similar evidences of wear. Wheels with flat spots requiring the removal of $\frac{1}{16}$ in. to ⅛ in. of material to bring them back to round, are ground. It costs us

about \$6 to remove $\frac{1}{8}$ in. of metal. The chill is usable for about $\frac{1}{4}$ in.; so we are usually able to grind off up to $\frac{1}{8}$ in. without going beyond the chilled surface on the wheel tread. Wheels are ground to match some other wheel if possible. Unmatched wheels are used for idlers.

Another common cause of misalignment, is from the slipping of the wheels in operation, due particularly to rapid deceleration and acceleration of the crane bridge. The crane should occasionally be run against the end bumpers to bring it back to square. However, to obtain any benefit from this, the bumpers must be kept rigid and carefully aligned so as to bring the crane bridge at right angles to the crane runway.

For checking the alignment of the bumpers, we have used the following method with very good results. Plumb bobs are dropped from each of the bumpers to the floor, as shown at A and at B in the accompanying illustration. Inasmuch as the rails on the runway prevent dropping the plumb bobs directly from the bumpers, a carpenter's square is placed against the bumpers and the plumb bobs dropped from the corner of the square as shown in the illustration. The distance from the center of the rail to the end of the square should be the same in every case where the square is used. In other words, the distance from the center of the rail to point A should be the same as the distance from the center of the other rail to point B; likewise, it should also equal the distance from the center of the first rail to point C. This will locate the points A_1, and B_1 on the floor beneath the crane runway. This distance is equal to the distance between the centers of the rails and is known as the span width. Now from the end of the bumper at the left, as shown in the illustration, measure down the rail a distance equal to the span width, as shown at C. By use of a square, drop a plumb bob from this point to the floor as at C_1.

We now have an isosceles triangle laid out on the floor as at C_1, A_1, B_1. If the angle at A_1 is a right angle then the bumpers are so placed as to bring the crane bridge to a right angle to the track runway; in other words, the end bumpers are properly aligned. If the angle at A_1 is a right angle, the distance from C_1 to B_1 will be equal to the span width multiplied by the square root of 2, or multiplied by 1.4142.

If this distance does not check, the point B_1 should be moved until it is at a distance from C_1 equal to the span width multiplied by the square root of 2, and also at a distance from A_1 equal to the span width. The new B_1 may now be projected up to the end bumper above it by means of a plumb bob, and the end bumper moved until it is in alignment.

This method may sound very complicated, but when it is actually tried out, it will be found to be very simple and the results obtained will be well worth while.

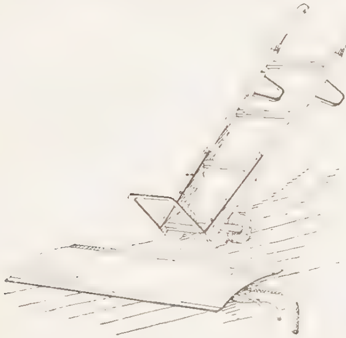
Electrical Engineer,
Detroit Seamless Steel Tubes Co.,
Detroit, Mich.

R. N. VINING.

Protecting Wire or Hose Lines Lying on Floor

In the use of portable electric or air tools it is often necessary to carry the lines across an aisle or other space where men are working or where trucking is necessary. Neither hose lines nor power wires will stand being trucked over without being damaged.

One method of protecting these wires is by the use of a special portable bridge, such as is shown in the accompanying illustration. This is made of sheet metal which may be of any thickness sufficient to stand the heavy or light traffic in the plant. A slight curve is made in this bridge to raise the center high enough so



This portable sheet metal bridge protects the electric power or hose lines for portable tools where they cross a passageway or aisle.

that air hose can lie beneath it without touching. The edges are bent so that they lie flat on the floor and also are beveled so as not to give an abrupt obstruction to the wheels of the truck. This bridge was made and is kept by the maintenance department and taken to any job where the men in this department find it necessary to use it.

Changing Electric Light Fixtures Saves $25.05 on Each

A new type of electric light fixture is being used throughout our plant because it is cheaper to operate and maintain than the old type. The old ceiling fixtures had a frosted glass reflector of the semi-indirect illumination type, which reflected approximately 40 per cent of the light against the ceiling. These old fixtures were installed in such a way that it was necessary for a man to climb up on steel girders and stand on an I-beam to pull a lamp fixture in where it could be cleaned and inspected. From 15 min. to ½ hr. was required to change a burned-out lamp and 40 min. or more was needed to clean the glass reflectors. This method of taking care of the lights was hazardous

both for the repair man and for those who walked underneath the fixture while it was being cleaned.

Today all of the old fixtures have been replaced by Thompson safety switch lamps with an Ivanhoe, R.L.M., 18-in. reflector, which is designed to throw all the light downward.

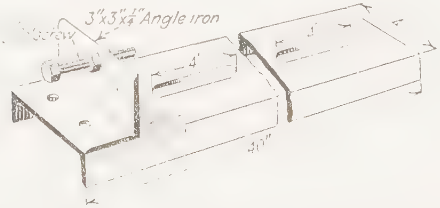
Instead of 750-watt lamps, 500-watt lamps are being used. As about five lamps per fixture per year are used and as the cost of each lamp is $2 less than the 750-watt lamp there is a yearly saving of $10 per fixture. The reduction in size of each lamp, 250 watts, also makes a saving in current. As each lamp is operated on an average of 11 hr. a day, there is a saving of 1,004 kw.-hr. per year per lamp, at a cost of 1.5 cents per kilowatt-hour. This represents a saving of $15.05 in cost of current. Therefore, the savings per fixture per year amount to $25.05.

Now that it is no longer necessary to climb up on the I-beams for repairs or to replace lamps, because the fixtures can be lowered to the floor, considerable saving in labor may also be credited to the new fixtures. The net cost of installing the new fixtures was $31.10 per lamp. By comparing this figure with the saving credited to the new installation it is evident that the saving in a year nearly pays for the cost of the new fixtures.

Maintenance Inspector,
Kaministiqua Power Co.,
Fort William, Ont., Can.
E. J. ELVISH.

Use of Channel Iron in Making Sliding Base for Motor

It became necessary recently to make adjustable bases for some motors that had been installed on endless belt drives without provision to take up the slack. These bases were made as shown, and found to be entirely satisfactory.



A slot was cut in the channel iron for the leg bolts of the motor, whose position is adjusted by a set-screw.

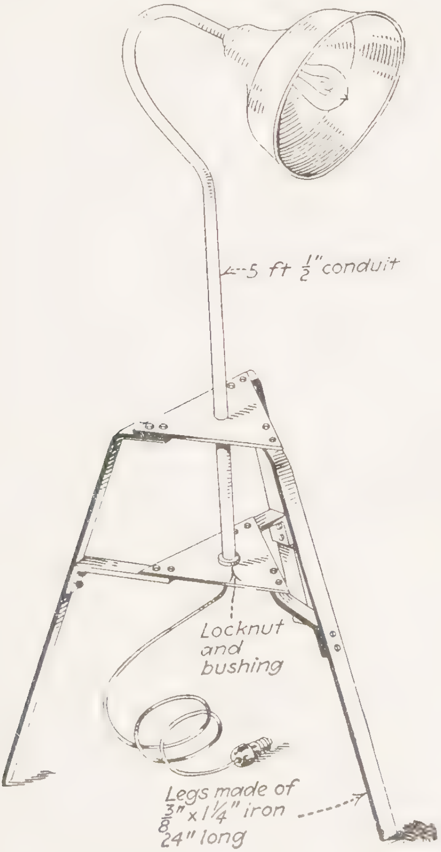
Slots 4 in. in length were cut in 4-in. channel iron to take the motor leg bolts, and a piece of 3-in. x 3-in. x ¼-in. angle iron was fastened on one end. The angle iron was tapped for a ½-in set-screw with locknuts to force the motor back so as to tighten the belt.

Two such slides were required for each motor. The length of the channel iron, however, varied according to the dimensions of the motors.

R. M. THOMAS.
Denver, Colo.

Portable Floodlight Made for $4.18

It suddenly became necessary to construct some sort of a temporary lighting system at the plant where the writer was employed in order to rush night work on an excavation job. Floodlights were out of the question, as the night work would not continue very long. To meet the emergency, the plant electrician made up



This shows the construction of a portable floodlight stand for use on a temporary job.

the lamp reflector and stand for holding it, shown in the accompanying illustration.

The total cost of each stand was $4.18, as shown in the accompanying itemized cost list of the various parts needed.

The two triangular-shaped pieces of iron used in the stand are ⅛ in. in thickness and were sheared from a piece of scrap iron. A 250-watt lamp is supplied with each stand, thus completing the lighting unit. Due to three legs being used rather than four, the lamp stands firmly, even though placed on rough ground. These

Cost of Floodlight Parts

Item—	Cost
Reflector	$[illegible]
Socket	[illegible]
Locknut and bushing	.06
5 ft. ½-in. conduit	.35
6 ⅜-in. x 1-in. [illegible]	.18
6 ¼-in. x 1-in. [illegible]	.12
6 ft. ⅜-in. x 1¼-in. [illegible]	[illegible]
3 short pieces of strap iron	.05
12 ft. No. 14 wire and plug	.20
Labor	.90
Total Cost	$4.18

outfits are light and easily moved from place to place, and yet they are strong and rugged enough for almost any purpose.

CHAS. A. PETERSON.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Grounding Machines to Prevent Static Discharges

Discharges of static or frictional electricity from machines used in manufacturing processes are always a source of annoyance and danger to the persons operating the equipment. There are cases on record where employees have been seriously injured, either directly or indirectly, by discharges of this kind.

Static electricity is generally developed on belt-driven machines that are set up on wooden flooring, or on a flooring having fair electrical insulating properties, and where the main drive shaft bearing brackets are mounted against a wooden ceiling. In many cases belts are grounded by means of metal combs placed close to the belt surface to remove the static charge.

The methods of preventing trouble from static electricity are extremely simple, and consist in grounding the frames of the machines to a suitable conductor going to earth.

There are, however, a few points to keep in mind when installing ground connections. As a rule, a ground wire is run to the nearest water or gas pipe, regardless of the conditions or the troubles that are quite likely to develop later.

Consequently a few suggestions may be helpful. In the first place, avoid grounding wires on fire sprinkler heads, steam pipes, gas pipes, meters, valves, and conduits. There is always danger of a pipe, especially a steam pipe, being insulated from the earth, or leaking

gas being ignited, with the possibility of frequent repairs making the ground ineffective for certain periods. Machine ground wires should be run so that they will not be mishandled and broken, to become a hazard to employees.

A simple and effective method of grounding any number of machines is to connect them to a common copper wire, say No. 6 B&S gage, which is carried along the floor and outside the building in conduit. The conduit serves merely as a physical protection for the wire which should be soldered or welded to a copper plate imbedded in several layers of charcoal placed at a sufficient depth to be in permanently damp earth. This method is recommended by the Department of Safety and Labor in several states.

E. A. BAERER.

Jersey City, N. J.

Easily Constructed Truck for Acetylene Outfit

A large sawmilling organization operating several logging locomotives and two large mills, maintains a repair shop for the up-keep of the engines and the sawmill and planer mill machinery. One of the most valuable tools in such a shop is the acetylene welding torch. To overcome any inconvenience when transferring the outfit about the shop or the yard, as is frequently necessary, the welding engineer has made a very handy truck from an old floor lumber truck.

The wheels and axle were first removed from the lumber truck or "dollie." The axle was bent at four places to right angles in order that the central portion of the axle would be dropped about 6 in. A rectangular frame was then made of ¼x1½-in. flat iron by bending two pieces 6½ ft. long to a U shape, allowing 1½ ft. across the bottom of the U. Two other pieces were formed into a 1½-ft. square and their ends welded together. These two squares were riveted to the upright sides of the U-shaped pieces, one at their top ends and the other 7 or 8 in. above the bottom. A piece of sheet metal 1½ ft. square was cut to form a bottom to the frame, and placed on the bends or horizontal portions of the U pieces. This formed a basket or framework 2½ ft. high by 1½ ft. square. Two ½-in. holes were then drilled through opposite edges of this metal bottom, so that it could be clamped by two U-bolts to the dropped portion of the axle.

Before setting the frame on the axle, one end of a piece of 1-in. rod, 4 ft. long was welded to the center of the axle. A 10-in. T was welded on the other end to form a handle or tongue for the truck. The wheels were then remounted and the oxygen and gas cylinders set upright in the rectangular frame.

L. M. JORDAN.

Cairo, Ga.

II

MECHANICAL

MECHANICAL

BELTS

Suggestions on the Application of Fasteners to Fabric Base Belts

The kind of fastener to be used on fabric base belts will vary as to type with different drives and the preference of operators; any of the better known fasteners or lacings will give good results if of correct size as specified for the work by their manufacturer. From an operating standpoint, it is essential that the ends of the belt be cut squarely and that the fastener or lacing holes do not cut the lengthwise threads of the fabric.

If a belt is not cut squarely it will have more load on one side than the other and will stretch or tear at the fasteners on the overloaded side, and being out of alignment, will not run true. If a belt which runs off to one side of the pulleys is taken off and stretched out on the floor, it looks like the arc of a great circle and is condemned as not having been made straight. This may be caused by not cutting the ends square, however. After a belt is curved it is almost impossible to straighten it.

Frequently a belt which is improperly installed runs so far off to one side of the pulley that a board is placed against the edge of the belt to keep it on the pulleys. Although belts are never intended for use as band saws, they are condemned if the edge frays after cutting through an inch or so of wood. Incidentally, the belt is torn on the short side by the fasteners and plies opened up; sometimes the plies break just behind the fasteners. When the plies are opened dirt and air will work in between them and be driven lengthwise through the belt by the pulleys. This causes "bootlegging" (opening up of the plies) and may result in a break anywhere throughout the belt.

Punching holes that cut the warp threads will, of course, weaken the belt by decreasing the serviceable width by the total width of the holes. Sometimes belts have a fifth of the entire width cut in this way and whether they fail or not, the punching is costing 20 per cent extra.

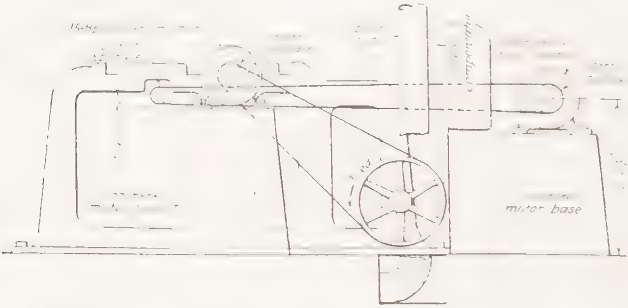
It is taken for granted that in aligning the pulleys that the crown or exact center of face have been carefully placed in line. Where the pulleys are not aligned the belt will "climb" to one side or run off the pulley face and make about half of the belt do the work. This throws an extra strain on the fasteners.

Chicago, Ill. E. D. F.

Driving Adjustable Spindle From Fixed-Position Motor

About two years ago it was decided to adopt motor drive for all the machinery in our main plant, which at that time was belted to lineshafting and driven by two Corliss engines. In looking over some of the various jobs tackled during the change-over period, one in particular stands out as very interesting—not so much from an engineering standpoint, perhaps, as from the ingenuity required.

Among the woodworking machines to change over was a Whitney, 30-in. double surfacer, or planer, which had previously been driven from a countershaft with a double-belt drive to each spindle. The position of the upper spindle was fixed, but the lower one could be raised and lowered about 7 in. to take care of different thicknesses of stock. The connection of the drive to the upper spindle was simple, as shown in the sketch. This spindle was direct-connected through a flexible coupling to a 15-hp., 3,600-r.p.m. motor, which was mounted



Method used to drive an adjustable-position spindle and a fixed-position motor by an open belt.

The two shafts are placed 6 ft. apart. The adjustable spindle at the left moves 7 in. on a vertical plane and so changes slightly this center distance, but not enough to seriously affect the drive.

on a concrete pedestal. It was not so simple to devise a method of connecting a motor directly to the lower spindle due to the construction of the machine, and also on account of the necessity of raising and lowering the spindle.

We finally decided to place the motor on the floor at the out-feed end of the machine and drive the spindle by means of a belt, using an idler to take up the slack necessary to compensate for raising and lowering the spindle head. While waiting for the arrival of the idler attachment, we got along by moving the motor on its slide rail to compensate for the changes in center distance. This was too much of a make-shift, so even before receiving the idler pulley we thought of the

method which is illustrated by the horizontal belt drive in the accompanying sketch.

It will be noted that the upper spindle is direct connected, as previously explained. The motor for the lower head is mounted on a concrete pedestal at the in-feed end of the machine, at the right in the accompanying illustration. The only precaution necessary was to have the center line of the motor shaft at a distance from the floor equal to that of the center line of the lower spindle when it was halfway between its extremes of travel. The motor was mounted to give a center distance of 6 ft. between the pulleys on the motor and the movable head and the belt cut accordingly. This center distance varied slightly as the spindle was moved up and down. This was taken care of by the elasticity of the belt.

Since this open belt transmission was installed we have experienced no trouble due to slippage. Another advantage is that heretofore wasted space is used. The machine is accessible from all sides. Because of the position of the compensator and the shaving pipe, it has not been necessary to use a belt guard.

Incidentally both motors are controlled by one compensator by using a relay for each motor. It has not been necessary to renew the line fuses since installing the motor as described.

J. F. Winn.

Plant Engineer,
The J. G. Wilson Corp.,
Norfolk, Va.

Suggestions on Care of Rubber Belting

Belt life is dependent to a very large extent upon the care given to the drive. The necessary attention for rubber belts is, in general, quite similar to that required for leather belts, although there are some points of difference which the belt user should thoroughly understand. Belt dressing, for example, is not necessary on rubber belts and the oils contained in a large percentage of the dressings on the market will injure the belt. Leather belts, however, require a certain amount of dressing containing oils to preserve the leather.

The use of resin and some forms of dressing, which appear to give the belt a better grip, will quickly pick up dirt, which cakes and forms a smooth, polished surface on the belt or pulleys. This causes slippage and defeats the intended purpose. All belts and pulleys should be kept clean.

Operating belts over pulleys or shafts out of alignment shortens the life of any type of belt. Babbit lineshaft-bearings wear, buildings "settle," bolts ease up, and other agents help to throw shafting and pulleys out of alignment. Many belts are abused by being held on the pulleys by guide boards and forced to run out of line. This wears away the protecting edge of the

rubber belt and opens up the plies at the side. It is seldom practicable to trim off the worn edge of a rubber or fabric base belt. Periodical aligning of shafting and pulleys will reduce belting costs.

When a rubber belt is cut or torn by accident, it is generally possible to repair the injured part or cut it out and put in a short section of good belt. Cuts or tears, which are not taken care of will soon extend, or cause ply separation throughout the whole belt, thus making it a total loss.

Determining Width of Belts From Alignment Chart

The width of a belt required to transmit a given amount of power depends on the allowable tension which may be placed on the belt, the speed of the belt and the arc of contact between the belt and pulley. This problem may be solved by means of the belt-tension

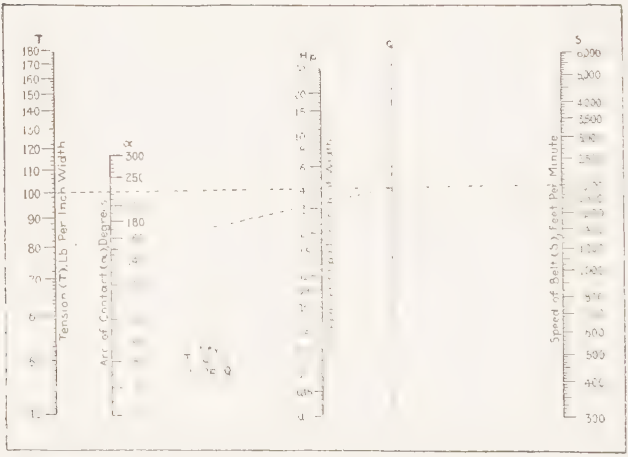


Chart for determining belt width with straight-edge.

Knowing the important characteristics of a drive, such as speed, tension (estimated), arc of contact and power to be transmitted, the belt width is determined as follows: Assume T (tension) is 100 lb. per in. in width; S (speed) is 2,000 f.p.m.; a (arc of contact) is 150 deg. and 20 h.p. is to be transmitted. Place the straight-edge on T and S scales as shown by dotted line and mark intersection with Q. Again place the straight-edge on Q and a scale and read the horsepower per inch on the *hp.* scale.

formula and the formula for horsepower of belts. For leather on cast iron the co-efficient of friction varies from 0.3 to 0.5. Assuming the minimum value of 0.3, the formula becomes:

$$\text{Hp.} = [TS(1 - e^{-0.005235})] \div 33.000$$

from which the accompanying chart was constructed. Solution of the formula is difficult for one not familiar with natural logarithms or the use of a "log-log" slide rule, and takes considerable time if it is necessary to make several trials to arrive at the desired proportions.

An example will best illustrate the use of the chart. Assume a set of values as follows:

Tension $T = 100$ lb. per in. of width;
Speed $S = 2{,}000$ f. p. m.;
$a = 150$ deg. arc of contact;
Hp. to be transmitted $= 20$.

Place a straight-edge across the chart between the points given on the T and S scales, as shown by the dotted line, and mark its intersection with the line Q. Place the straight-edge again from this point on Q to the value given on the a scale, and read the value on the Hp. scale, which in this case is 3.3 hp. per in. of width. Since the horsepower to be transmitted is 20, the width of the belt must be $20 \div 3.3$ or approximately 6 inches.

The maximum allowable value of T may be obtained from the manufacturer of the belt, or by testing a piece in a tension machine and then applying a suitable factor of safety. In case the arc of contact is not the same for both pulleys of a system, the smaller should be used, as slippage would tend to occur first on that pulley. The chart may be used to solve for any other quantity in case the width is known, so long as the two readings with the straight-edge are taken on the proper scales, according to the key given on the chart. If it is desired to find T, all other values being known, the reading a-$hp.$-Q. is taken first, then S-Q-T. If readings are carefully taken, the greatest error will be less than 5 per cent.

K. M. White.

Mooresville, Ind.

Recommendations for Applying Belt Dressings

When a belt is bent around a pulley the internal fibers rub on each other. Unless the fibers are properly lubricated their resistance to wear is lessened, resulting in a shorter life, according to some information on belt operation, issued by Chas. A. Schieren Co. A suitable dressing provides the necessary lubrication to reduce this wear.

All belting should be dressed periodically. In very dry places it is good practice to dress a belt lightly every two or three weeks; in other places belts may need attention less often, depending on the service and amount of dressing applied. Many belt men apply a preservative dressing to the outer ply and allow the greases to penetrate through the leather. If the inside surface is very dry, a small amount is applied to this surface until it softens. By applying most of the dress-

ing to the outside the surface never becomes slippery. It is not necessary to wait for a shutdown or weekend; but dressing can be applied while the belt is in operation, or at the noon period.

Applying the dressing to the outside of the belt is very good practice for belts operating in dusty places, such as flour mills, and so on. The application of a dressing to the outside, after brushing the dirt off, keeps the pulley surface from becoming gummed up. This keeps the belts in the pliable condition necessary for economical service.

Often the face of a cast-iron or split-steel pulley will become very shiny. This condition means that the belt is slipping and polishing the surface. Sometimes this condition requires the use of a larger belt. Leather belts that polish the face of the pulley do so because they have been allowed to dry out and become harsh and hard on the surface.

The application of a good belt dressing that will soften up the harsh leather surface will remedy this trouble. The shiny surface will disappear and a dull, smooth one take its place. It is this latter type of surface that is capable of transmitting heavy loads.

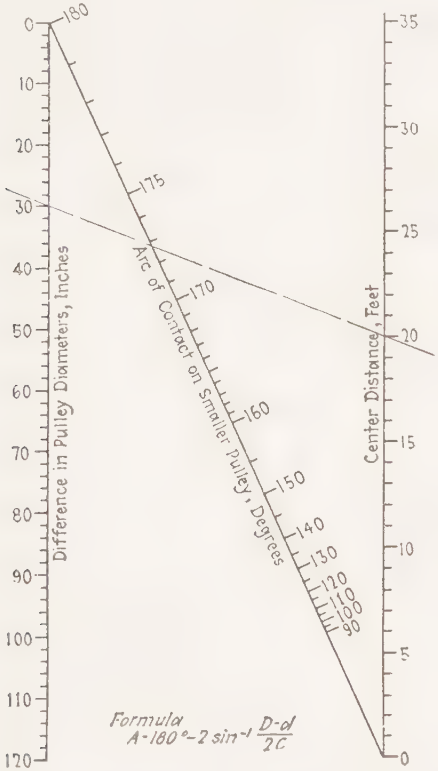
Chart for Determining Arc of Contact on Belt Drives

In laying out a belt drive the arc of contact should be as close to 180 deg. as possible. A 180-deg. arc of contact is possible, however, only when both pulleys are of the same diameter. It is not considered good practice in any case to have the arc of contact on the smaller pulley less than 165 deg. Below that point a belt must be run at a very high tension to make up for the loss in arc of contact or some type of belt wrapping device used. If it is necessary to operate a belt at a lower arc of contact, allowance must be made in the capacity rating. For example, at an arc of contact of 160 deg., a belt will transmit only about 90 per cent of its rated capacity. With decreasing arc of contact the power-transmitting capacity decreases rapidly, until at 140-deg. arc a belt will transmit only 80 per cent of its rated capacity.

Wherever possible it is advisable to increase the distance between centers, which will increase the arc of contact. The accompanying chart may be used to determine quickly the arc of contact for various diameters of pulleys set at different center distances, until a satisfactory layout has been carefully established.

This chart is used on open drives where the belt is practically without sag. The method of using the chart is as follows: Locate the difference in pulley diameters in inches on the scale at the left and the center distance in feet on the scale at the right. When these two points are connected with a straight-edge which may be either a fine thread, or preferably a celluloid

rule, the arc of contact on the smaller pulley may be read off at the intersection of this line with the center diagonal line. The formula on which this chart is constructed is shown at the base of the chart.



Method of using chart for determining arc of contact.

This chart was prepared and copyrighted by J. E. Rhoads & Sons, Philadelphia, Pa. In the instance illustrated, the large pulley is 30 in. greater in diameter than the small pulley, and the center distance is 20 ft. The intersection with the center line of the line connecting these two points on the corresponding outside scales indicates that the arc of contact would be approximately 173 deg.

Chart for Determining Belt Speed

For effective operation of leather belts in the transmission of power, it is always well to keep the belt speed high because the power transmitted depends upon the speed and the size of the belt. Thus, at high speed

narrower belts can be used. In any installation it is usually possible to lay out a drive for any one of a number of belt speeds because a constant reduction ratio between the pulleys may be obtained by the use of several different combinations. To check the belt speed of these combinations, operating men will find

The chart below is used as follows, for determining belt speed.

Assume that a 32-in. pulley is located on a shaft operating at 230 r.p.m. Place a straight-edge or ruler at 32 on the scale at the left and at 230 on the scale at the right. The intersection with the center scale gives the belt speed as 1,900 f.p.m. This chart was designed and copyrighted by J. E. Rhoads & Sons, Philadelphia, Pa.

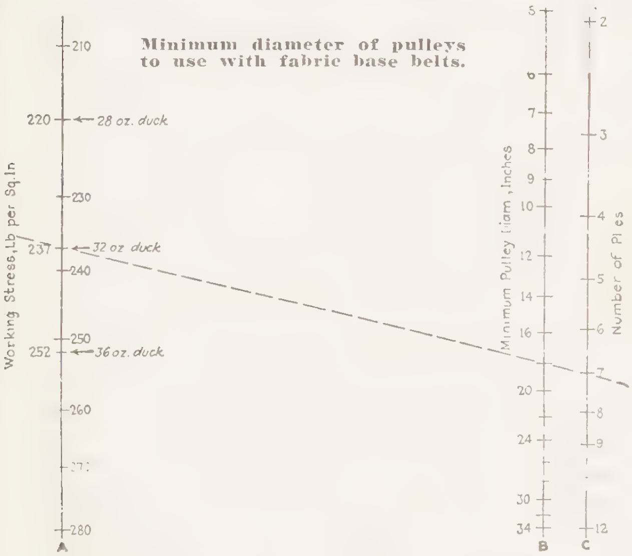
the accompanying chart very convenient. To use this chart, it is necessary to know only the pulley diameter in inches and the revolutions per minute of the pulley; both of these factors are usually known or determined in advance.

With this chart the belt speed in feet per minute is determined by the intersection on the center scale of a straight line drawn from the point on the scale at the left, corresponding to the pulley diameter in inches, to the point corresponding to the r.p.m. of the pulley on the scale at the right. This same chart can be used to determine the surface speed of pulleys in the same way.

Determining Size of Pulley for Fabric-Base Belts

Where fabric-base belting is made up of several plies of stitched or cemented canvas, pulleys of small diameter should not be used because of the danger of pulling the plies loose when making the short bend.

The proper size of pulley to use with such belting of various weights and plies may be determined by means of the accompanying chart which takes into consideration working stresses ranging from 210 to 280 lb. per



Place a straight-edge to intersect column A at value of working stress or weight of duck, and number of plies, in column C. Read diameter of pulley at point of intersection with column B.

sq. in. The three most common weights of duck used in belts, 28 oz., 32 oz., and 36 oz., have corresponding working stresses of 220, 237 and 252 lb. respectively. These stresses are given in column *A*. Column *B* gives the minimum pulley diameter in inches and column *C* the number of plies. With this chart any of these three factors may be found if the other two are known.

The method of using the chart is best shown by an example. Thus, if a seven-ply belt is made of 32-oz. duck, what minimum pulley diameter may be used? To find this run a straight line through the point in column *A* corresponding to 32-oz. duck and figure 7 (number of plies), in column *C*; the intersection of this line with column *B* indicates that the minimum pulley diameter that should be used with such a belt is 18 in.

In other words, simply run a straight line through the working stress, column *A*, and the number of plies

Data for Proportioning Fabric-Base Belts

Belt Width, Inches	Number of Plies, Minimum	Number of Plies, Maximum
2	2	3
3	3	4
4	3	5
5	4	5
6	4	5
8	4	6
10	4	6
12	4	6
14	5	6
16	5	6
18	5	6
20	6	7
22	6	7
24	6	7
26	7	8
30	7	8
36	8	10
42	8	10
48	8	10
54	10	12

in column *C*, and the intersection of this line with column *B* will give the minimum pulley diameter. Extremely small pulleys must be avoided, if it is at all possible to do so. Thus, column *B* shows that no pulley smaller than 5 in. in diameter should ever be used with a standard fabric belt.

This chart is based upon the following rule: Extract the cube root of the working stress in pounds per square

inch, multiply by the number of plies and divide by 2.4. The result is the minimum diameter of the pulley in inches.

This chart may also be used for determining the maximum number of plies when the working stress and the pulley diameter are known, by simply running a straight line through the two known factors.

The accompanying table will assist in the selection of a well-balanced belt that will be neither too thick nor too thin. Thus, for instance, if the belt width is 10 in. it is generally considered best not to use less than four or more than six plies. This table used in conjunction with the chart will be found to be very useful when laying out fabric-base belt drives.

Mechanical Engineer,
Newark, N. J.
W. F. SCHAPHORST.

BEARINGS

Precautions to Take When Using White Metal for Rebabbitting Bearings

The rebabbitting and fitting of white metal bearings is one type of work which is largely dependent on the mechanic's skill and even the best mechanics fail occasionally. One of the principal pitfalls in this work lies in the delicate and unstable chemical composition of the white metal itself. If the metal is not carefully treated in heating and pouring, although the bearing may be poured successfully, the resultant bearing surface may not have the wearing qualities expected.

White metal is not the same as other bearing alloys, as the terms are generally understood. If the surface of the white metal is examined under a microscope, a number of hard crystals are shown immersed in a plastic material, much in the same manner as hard stones are immersed in a plastic tar compound in some of the road building materials. When installed in a bearing the journal presses on the bearing surface and the load is carried on the hard crystals; however, the plastic material yields and allows the load to be distributed evenly over the whole surface. This, at least, is what should happen in practice but, unfortunately, a good texture of metal is difficult to form and easy to damage.

Every white metal alloy has a critical temperature and, if it be heated much above this point, oxidation of the metals occur; this may lead to the inclusion of undesirable oxides in the poured metal itself. Metal oxides are hard, tin oxide approaches the hardness of hardened steel; if this oxide is on the bearing surface the result will be increased friction and overheating and it is also possible to slightly score the shaft. If the metal has been overheated a careful stirring as it cools down will remove, at least partially, the ill effects.

Molten white metal should always be kept well stirred; otherwise, its various constituents will not be uniformly distributed throughout its whole mass. The rate at which the bearing is cooled off after pouring is important; too rapid cooling results in a partial or complete prevention of the separation of the hard particles. These compounds remain partly dissolved and even if and when they do segregate, their size remains small. Too slow or retarded cooling causes excessive growth of the harder constituents and a general coarsening of the microstructure; this embrittles the surface.

The rapidity of the cooling process is partly dependent on the pouring temperature, the temperature of the shell and mandrel, and, also, on the surrounding atmospheric temperature. If the pouring is done in a cold and exposed position, cooling will be rapid; if done in a hot room, such as a furnace room or foundry, cooling will be slow. The bearing shell should be heated before pouring, and the atmospheric temperature should be moderate; the observation of these conditions should help to obtain satisfactory results.

In all babbitting of bearings it is important that the shell be thoroughly cleaned and tinned before pouring; otherwise, the metal may not make a tight joint with the inside of the shell and shrink away when cooled. Also, with a solid union of the metal to the shell any heat generated between the shaft and the bearing will be conducted through the white metal to the shell and thence to the metal supports and dissipated by the large radiating surface. If the cleaning and tinning of the shell is not carried out properly, even assuming that the lining is securely fixed to the shell mechanically, the thermal conductivity will be bad and heat will not be transmitted between the white metal and the shell as it should be.

W. E. Warner.

Shefford, Bedfordshire, England.

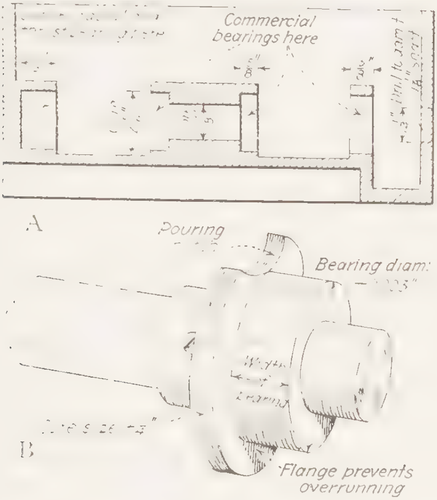
Babbitting in Bearing Seats for Ball or Roller Bearings

Use of ball or roller bearings, when rebuilding old equipment or when constructing new or special machinery, is often passed up on account of the cost, which is made up of two items: namely, the cost of the bearing itself and the cost of making the bored and capped seat for the bearing. This higher first cost often causes the anti-friction bearing to be thrown out on a design in favor of its less expensive, plain competitor, without regard to future service or to ease of renewals.

The benefits of anti-friction bearings at lowered cost may be secured by setting these bearings in babbitt seats. This makes an inexpensive mounting that is exceedingly durable on a wide range of machines, although not usable in all cases. The writer has mounted a number of Timken and New Departure bearings of No. 305 size and larger in this manner and feels

sure that the construction is satisfactory because the machines have been out in use for some time and no complaints have ever been registered.

Recently, some special material-handling machinery was built in which the practice of babbitting in was followed. For example, a gear box for one of these machines contains four bearings in a length of 12 in., as shown in *A*. Three of these bearings were inexpensive, commercial ball bearings, whereas, the fourth was



Fixture for casting babbitt seats for ball or roller bearings.

Three commercial ball bearings and a Gurney radial and thrust bearing were to be placed in the gear box *A* of a special machine. The holes for the shaft and bearing were cored out and a mandrel fitted with flanged babbitting dummies *B* to cast seats for the bearings. This method of seating ball or roller bearings may be used on certain types of work at a saving in installation expense.

a Gurney ball bearing which takes both thrust and radial loads. Thus the easy running and cheap renewal qualities of ball bearings, were secured at a minimum of cost.

Cored holes in the cast-iron case, *A*, allow the shaft to pass through with ample clearance. The bearings were set in larger recesses at the ends of these cored holes. The method of installation used was to have a plain shaft for babbitting purposes. On this shaft were placed dummies of the same size as the bearings. These dummies consisted of cast-iron collars *B* with setscrews in the hubs, which were placed at measured intervals along the shaft after the latter had been set inside the casing. Babbittrite was used for the

dam and the shaft was positioned by measuring from machined surfaces on the case.

The case was heated and the babbitt was poured at a low temperature. Anchor holes for the babbitt were placed in openings in the cast-iron case to insure a tight fit of the babbitt in the casing.

Upon removal of the dummies, the bearings were inserted. The collars were 0.003 in. smaller than the bearings, so that the bearings had to be squeezed into position. This holds the bearings tight and presses the babbitt back into the casting. A further advantage of the babbitt seat is that it makes possible the use of anti-fraction bearings by shops that do not have boring facilities, because shafts can be placed without machine work. Also it makes possible a last-minute change or a shift in position to make gear centers come better or parts engage as they need to be, as found necessary while assembling.

The drawing *A* shows the half gear case mentioned. The same size of core was used throughout, which lessens the pattern cost and leaves ample room for both makes of bearings. For manufacturing reasons, the end hole (where the shaft is put through) is drilled and can be plugged, if it is desired to run the gears in oil. The collar of dummy *B* may be left plain or made with a flange. The flange prevents overrunning and end-trimming after pouring and where more than one job is to be done, it will pay for itself.

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Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Precautions to Take When Installing Ball or Roller Hanger Bearings

Ball and roller lineshaft bearings have established for themselves a permanent position in industry. The saving in power, less frequent lubrication, and cleanliness are points that should not be overlooked. Tests have shown in a number of instances that the saving in power will pay for the installation in a comparatively short time.

However, there is one factor in connection with the use of such bearings that is likely to cause trouble unless care is taken in the installation. This is the problem incidental to getting bearings of the solid ring type off the shaft when this becomes necessary. Practically always the bearings are put on "to stay," because it is thought that there will be no changes made in the shaft layout. However, all industrial operating men know that practically all assemblies that are put up to stay have to be taken down at some time. For example, a new management decides upon a shifting of machines or a general repowering; or a shaft hanger breaks, a sleeve loosens enough on the shaft to score or to allow the shaft to pound, or a solid cast-iron pulley has to be taken off the shaft. Again, perhaps

some accident has been severe enough to bend the length of shaft or to crack a bearing cone.

These are some of the things which experienced maintenance men know might happen. No one can foresee them, but if any one of them did happen, one or more bearings would have to be taken off the shaft. Frequently the discovery is then made that the bearing has rusted on the shaft during its period of service.

I have found that this factor enters regardless of whether cast-iron or steel sleeves are used in contact with the shaft, or in internal contact where the parts related do not move. In a number of cases the sleeve has been rusted so tightly that it could not be removed.

In such cases it is usually necessary either to shatter the ring members so they can be picked out in small pieces or to saw off the shaft close to the bearing in order that it may be forced out in a press. A job of this kind involves taking the shaft down, whereas this would not be necessary if certain precautions had been taken at the time of installation.

Before installing bearings it is customary to wipe off the shaft and bearings so that they will be clean and dry. This leaves oil or grease only on the balls or rollers, and so the parts are put together dry in what would seem to be the best possible condition for service.

In the course of a few years it will be found that these same dry parts have rusted badly, thus creating a strong bond between parts which are already mechanically tight. This difficulty seems to be independent of the so-called "improved" designs of clamping members; it must always be considered where iron or steel parts are in contact.

The majority of men have sweaty hands, not necessarily the wringing wet kind, but exuding an unnoticed dampness that will pave the way for corrosion due to atmospheric action. Given time, rust will as surely cover the spots that the men touch as it will the finished cast-iron surface that has been marked with common chalk. The rubbing of the hands over a shaft or inside a hole as the last act of cleaning off before assembly will be the cause of rust starting.

The only way to avoid this trouble is to oil or grease all surfaces of the several parts before they are put together. Rusting takes place at the points of contact that have no relative movements. This difficulty is serious enough to merit attention from all operating and maintenance men. In the days of plain bearings it was a simple job to replace the bearings if they became worn, but ball or roller bearings are of necessity more difficult to handle. The man who has not done any of this work would naturally think that the bearing would come off with about the same amount of labor as was employed in putting it on but actually it does not.

When the job of changing a bearing comes up, he gets a helper and starts to do it, thinking that he will

get the job done in a few hours' overtime. However, he finds that rust has preceded him and he has to recruit his force to double the number of men and to work all night.

The new ball and roller hanger bearings have not been in use a sufficiently long time to require changing and so the difficulties of removal are not generally realized. In many cases, too, the men who have to take the shaft down do not have any idea what was the cause of this trouble, nor how to prevent it in the future.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Using Oxyacetylene Torch When Relining Bearings

Not only is the oxyacetylene torch useful for welding and cutting around the industrial plant, but it can also be used as a source of heat for removing babbitt from old bearings and also for babbitting, according to the Smith Welding Equipment Corporation, Minneapolis, Minn. The flame is easily adjusted to the proper temperature and saves much time in melting out the old metal and burning off the grease for cleaning the bearing mold. The tip used need not be large and should be kept in motion by playing over the old metal until it is all melted out, but care should be taken not to burn the metal. Playing the torch flame over the mold will burn out the oil or grease and any other foreign matter, and dry up the bearing so that a wire brush will clean it perfectly.

Preheating the bearing mold for a new lining is a most important part of the work, because the babbitt will not adhere to cold metal. The difficulty of heating and then placing the bearing in place for the pour is well known to anyone having this work to do. Using the torch simplifies the work to a great extent, because with it the mandrel or shaft can be warmed up and the bearing molds heated while in place. The melting pot should then be heated, and after adding metal, the heat for melting is supplied by playing the torch flame on the bottom of the pot. Any desired temperature of bearing mold and pot metal can be obtained and a perfect pour made.

Often a worn or scored bearing can be repaired with the torch. The lining must first be washed with lye water and all traces of oil removed. By using a filler rod of babbitt metal, the scores are built up and the bearing can then be scraped in. Building up worn brasses and babbitt metal bearings requires skillful manipulation of the torch. Spots are built up and allowed to solidify; the welder works each spot toward the center of the bearing and finally completes the welding work at this point.

Making a weld near a bearing will often necessitate repouring the bearing unless some precaution is taken to prevent the soft metal from melting. Frequently repouring can be avoided by placing a piece of pipe, approximately the size of the shaft, in the bearing and circulating water through it.

The valve gear on feed pumps wears out constantly and probably gives more trouble from lost motion than any other part of the plant equipment. The easiest and quickest method of repairing is to fill up the valve rod heads with steel or bronze by using the torch and drill out for the pin.

Worn bearings in the crosshead stand can be repaired best by welding in cast iron to a depth of 1 in. and drilling out for the rocker shaft. It will be necessary, in order to fill up the old bearing space, to back it up with asbestos or carbon paste.

In one case the partition between the valve chambers on a feed pump had become so pitted that the gasket would not hold, although the remainder of the pump was in excellent shape. This part was built up with bronze, which was dressed down by hand, and has been in use two years without replacing a gasket.

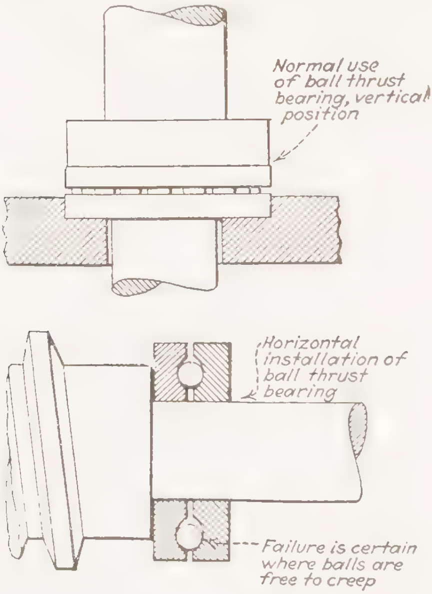
Improper Use of Thrust Ball Bearings on Worm Causes Trouble

Thrust ball bearings are not so commonly used as are radial ball bearings. Unless full consideration is given to the detail construction of the bearings and the manner of mounting, the bearing may fail apparently without cause. One such case was in connection with a ball thrust bearing on a worm drive. The worm was mounted horizontally with radial ball bearings and in addition thrust ball bearings were used at each end to take the worm thrust. Every few weeks, the thrust bearings would fracture or the balls would break. According to the manufacturer's ratings for the bearings, they were of sufficient capacity to sustain the thrust loads which were imposed on them.

After considerable experimenting, one of the engineers suggested that the balls in the bearing be mounted in a cage to prevent their shifting position. When this was done the bearing trouble ended immediately. Manufacturers generally recommend the use of a cage or retainers to space the balls properly and keep them in position. Many times, however, attempts are made to apply balls without such a retainer.

The explanation of this trouble described above is that a thrust bearing, when mounted with the ball race horizontal, will operate without any difficulty. When it is placed on edge, or in other words with the axis horizontal, the balls creep between the sections of the races when the screw is reversed, causing the races to separate. This causes the balls to be caught

out of position when the load is again reversed and applied on the thrust bearing. The lowest ball then carries the major part of the load and either or both the ball and races fail. The use of a cage maintains



How the thrust load is applied on vertical and horizontal ball races.

When a thrust ball bearing is used on a horizontal shaft the balls may be crushed, as shown in the lower drawing, unless a cage is used to retain the balls in their proper position. The conditions are different with vertical thrust and loads, as indicated in the upper drawing.

the alignment of all the balls in their proper positions, distributes the load uniformly and so prevents further trouble from such sources.

G. A. LUERS.

Washington, D. C.

Selecting Proper Babbitt for Armature Bearings

Babbitt metals may be divided into lead-base and tin-base metals. The former finds far wider application on electric motors, as it is somewhat cheaper and gives very satisfactory service. The friction co-efficient is somewhat lower for lead-base babbitt, which is not quite so hard as tin-base babbitt. For general-purpose motors in coupled, belted, and ordinary geared service,

the results are very satisfactory. Where very high speeds are encountered, tin-base babbitt is preferred, on account of its lesser tendency to "gall" or wipe.

Lead-base babbitt must be handled with great care; it has been found that the best temperature for handling this babbitt is around 460 to 490 deg. C. (860 to 914 deg. F.). If handled at temperatures much below the low point, segregation is likely to occur; if handled at higher temperatures and exposed to them for a considerable length of time, oxidation will occur and the metal may be ruined.

On motors used for severe service where vibrations are not only severe, but of a hammer-blow nature, it is preferable to use a bronze shell, tinned, and lined with babbitt, about 1/32 in. thick. The bronze is used for the purpose of insuring proper amalgamation, the babbitt being virtually soldered into place. With only a thin layer of babbitt, there is not much tendency for it to pound out of shape, as it is supported by the harder bronze.

Bronze shells without babbitt are not used to any great extent on electric motors. Bronze has a higher co-efficient of friction and expansion, requiring a larger bearing clearance than is used for babbitt. The higher friction co-efficient causes greater heat development and if the running clearance is held too small, it may happen that the bearing will be tight on the shaft and rotate with it in the housing. If the housing is strong enough to prevent expansion, the shell will be compressed and become tight on the shaft. On the other hand, expansion may break the housing.

The babbitt-lined, bronze shell insures a lower co-efficient of friction and hence less heating. In some cases, it has been found sufficient to merely heat the bronze shell and tin the bearing surface. The shell is bored out to size and after tinning, a sizing reamer is pushed through in order to smooth off the bearing surface, which still retains the tin coating, showing that the tin has amalgamated with the bronze.

This process has given good results, but the 1/32-in. thick coating mentioned before is better to use, since it has longer life. After all, the arrangement of oil grooves and provision for lubrication are very important factors in the life of a bearing, and have considerable influence upon its performance. A high-grade babbitt may not always give satisfactory results if the bearing is incorrectly designed or neglected.

Mechanical Engineer,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

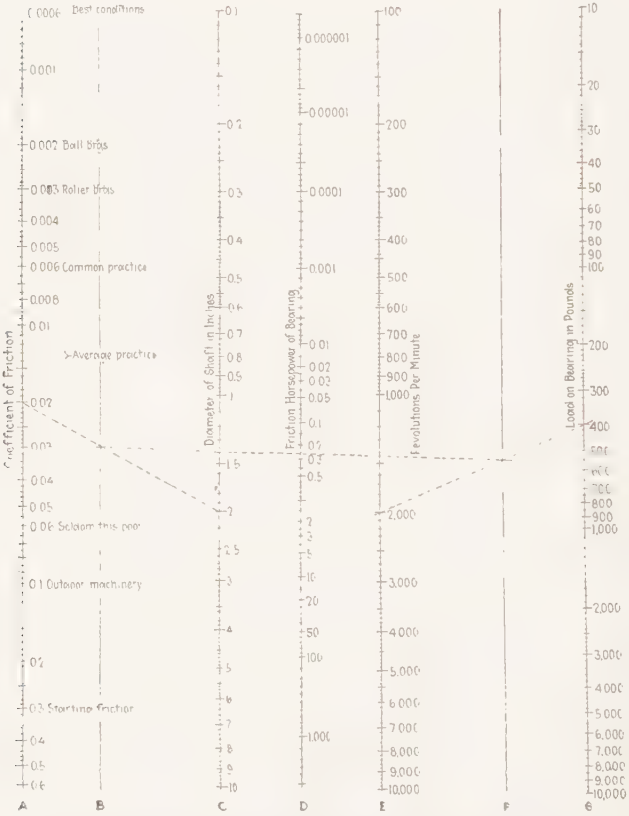
R. PRUGER.

Using Chart to Determine Horsepower Loss From Friction in a Bearing

The principal function of the accompanying chart is to speed up computations on bearings and their friction

losses. The ease with which these computations can be made with this chart should increase the use of actual figures in bearing design and operation, instead of the rough estimates or guesses, that are frequently employed.

To use this chart, it is necessary to lay a straight-edge across it three times, as indicated by the dotted lines. It will give the horsepower consumed by any



With the factors which affect friction, known or estimated from practice, the horsepower loss in any bearing can be easily determined by using this chart.

bearing with co-efficients of friction varying from 0.0006 to 0.6, with shaft diameters from 0.1 to 10 in., at speeds from 100 to 10,000 r.p.m., and with a load on the bearing varying from 10 to 10,000 lb.

For example, assume that in a particular bearing the co-efficient of friction is 0.02 (column *A*) which is

average practice for plain bearings, the shaft diameter is 2 in. (column *C*), the speed is 2,000 r.p.m. (column *E*), and a 400-lb. load is carried by the bearing (column *G*). Column *D* gives the friction loss as a little over 0.25 hp. To get this result connect with a straightedge the known value in column *A* with that in column *C* and locate the intersection with column *B*. In the same way connect columns *E* and *G* and locate the intersection with column *F*. Then connect the intersections (columns *B* and *F*), and the intersection with column *D* will give the friction horsepower loss of the bearing.

The notations alongside column *A* indicate the co-efficients of friction met with in everyday practice, beginning with the very best conditions of plain bearings and ending with starting friction. Co-efficients of friction under the many possible conditions may be obtained from text books, such as Alford's "Bearings" and in such handbooks as "Kent" and Mark's new "Mechanical Engineer's Handbook." Only the safe values of approved practice are designated on the chart. As will be noted, a co-efficient of 0.002 is used for ball bearings and 0.003 for roller bearings. All the other co-efficients (column *A*) relate only to the plain bearings.

The chart can, of course, be used backward as well as forward. For example, if the power absorbed by a given bearing is known and the values in columns *C*, *E* and *G* are known, the co-efficient of friction may quickly be determined. Then, knowing the co-efficient of friction with a given oil and in a given bearing, the power required by a similar bearing of different diameter, speed and loading may be found with an accuracy sufficient for most practice.

W. F. SCHAPHORST.

Mechanical Engineer,
Newark, N. J.

Precautions to Take When Rebabbitting Bearings

In the rebabbitting of bearings the following three factors are of prime importance: The bearing metal, the temperature at which it is poured, and the temperature of the shell and mandrel. The composition of the babbitt should be suitable for the service conditions. The two principal factors determining the composition of the babbitt are speed and pressure. In highspeed operation with a light or medium pressure, it is well to use a babbitt with a fairly high percentage of lead. For severe operating conditions, due to high pressure, at any speed, a relatively high percentage of tin must be used in the bearing to give sufficient compressive strength. As bearings operate under a wide variety of conditions intermediate between the extremes of pressure and speed, a correspondingly wide variety of bearing compositions may be used. The accompanying table indicates some of the alloys which

have been found satisfactory for various purposes as indicated.

The best composition for any particular service is dependent upon operating conditions and may be made valueless by heating the metal to too high a temperature, or by pouring it when it is too hot or too cold. Greater care must be exercised in seeing that a lead-base babbitt is poured at the proper temperature than is the case with a tin-base alloy. For this reason, it is well to use electrically heated melting pots with some type of thermostatic control, which will heat the metal to a certain temperature and keep it there until used.

The first step in babbitting a bearing is to clean the shells, which may be made of cast-iron, cast-steel, steel or bronze. Cast-iron or cast-steel shells are usually used without tinning. When rebabbitting an old bearing all of the old babbitt must be removed by heating the shells until it is melted out. Oil, dirt, or other foreign matter attached to the shell may be removed by dipping it in a strong solution of caustic potash or by burning. If the latter method is used the presence of smoke indicates that all oil and dirt have not been burned off the shell.

The next step is to scrape the surface to remove any scale. Steel or bronze shells, which are usually tinned, may be cleaned by heating them, preferably in a pot of scrap babbitt, until the old metal is melted out. As soon as the old metal is removed, the tin surface should be cleaned by coating it with zinc chloride; then dip the shell into a pot of molten solder (50 per cent tin and 50 per cent lead) which should be maintained at a temperature between 630 and 670 deg. F. Best results will be obtained by babbitting these shells while they are still hot and without handling. If permitted to cool, the tin surface should be wiped off before refilling.

When tinning a shell it is necessary to cover the parts on bronze or steel shells which are not to be tinned with a clay wash or thin mixture of graphite and water. When this is dry, the parts to be tinned should be swabbed or washed with zinc chloride and the shell then immersed in a pot of molten solder which should be maintained at a temperature of about 680 deg. F. The shell should be permitted to remain in the

Composition of Babbitt Adapted for Various Bearing Services

Application	Tin	Lead	Antimony	Copper
Shafting and heavy machines	80	..	10	10
	75	..	15	10
	70	10	10	10
Bearings on machine tools and millwork..	55	25	15	5
	50	27	19	4
	20	40	37	3
Light machines.......	10	75	15	..

solder until it is heated through. This is indicated by the excess of solder running off quickly when the shell is removed. A thin coating will, however, remain on the surfaces to be tinned.

It is well to remove the shell from the solder pot and again rub the tinned surfaces with zinc chloride and dip into the solder bath as before. This operation should be repeated as long as any spots which have not been thoroughly tinned can be detected. For tinning solder is preferable to babbitt in that it has a lower melting point.

The rate at which the bearing metal cools after it has been poured is very important and can best be regulated by pre-heating mandrels and shells. Ordinarily, for cast-iron or cast-steel shells which are untinned, the mandrel is preheated to about 300 deg. F., and the shell to around 210 deg. F. If the shell is too hot, the metal will cool too slowly, which sometimes results in a partial segregation of the metal in the alloy that may make one part of the bearing too hard and another too soft. Where the shell is too cold, the babbitt metal in contact with it is chilled too suddenly and may shrink away from the shell. The use of oil on the mandrel is objectionable because it causes blistering. Satisfactory results can usually be obtained by coating the surface of the mandrel with a clay wash applied with a rag.

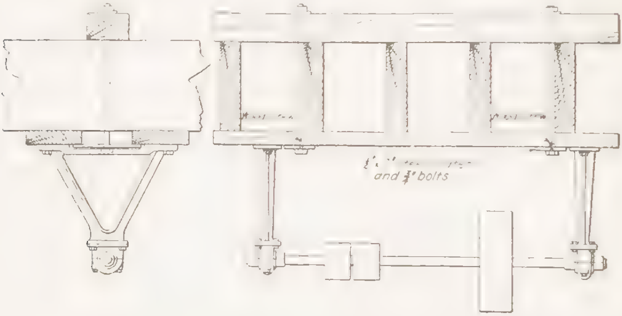
If necessary the mandrel may be cooled between pourings by dipping it in the clay wash, instead of swabbing. The proper temperature of the mandrel is indicated by the clay wash drying quickly, but without spattering. As stated before, the bronze or steel shells are preheated in the tinning process and should be babbitted immediately.

LINESHAFTS

Mounting Countershaft to Allow Easy Adjustment

Alignment of a countershaft with the machine it drives is sometimes accomplished with considerable trouble, especially where the shop is crowded and a machine must be placed where there is room instead of where it should be. Countershafts to screw machines, which are usually set in staggered formation, often present difficulties of this nature and so do other machines in which the belt is twisted. For this reason the commendable practice of fastening machines to wooden blocks imbedded in the cement and thus having some adjustment, instead of fastening them down by bolts set in the concrete is more and more coming into use. However, even this is not always adequate, and it is frequently necessary to resort to the laborious job of moving the countershaft.

One way to sidestep troubles of this nature is shown in the accompanying illustration. This method is as simple as it is easy, inexpensive and effective; also, it has good points beyond facilitating the adjustment of the countershaft, which was the main object. The plan consists of suspending the entire countershaft assembly, mounted on the wooden stringers, from two or three stout steel plates hung from a timber placed crosswise over the top of the available ceiling construction.



This countershaft can be shifted until aligned before fastening.

The assembled countershaft, mounted on stringers, is held up by the long ¾-in. bolts extending from the steel plates through a 4x6-in. beam above the joists. In this way the countershaft can be shifted a considerable amount by loosening the nuts and tapping into position. Tightening the bolts will hold the countershaft in position, although a lagscrew or two through the stringers and into the joists may be added if desired.

For the countershafts in question which were for Nos. 00 and 2 B & S screw machines, ½x4-in. machine steel plates were used. The plates were placed as close to the hangers as possible and fastened in place on the wooden stringers by a stout screw in each. On the larger machines 4x6-in. wooden blocks were used instead of the steel plates and a timber of a similar size was used above the overhead structure. Two ¾-in. bolts, as shown, extended up through the steel plates into this overhead timber.

A countershaft fastened in this way costs comparatively little, if any, more than by the usual method of lagscrewing it fast. Adjustment relative to the machine, instead of being the usual cumbersome and difficult job, is reduced to a trifling matter of loosening the two nuts on the ¾-in. bolts, tapping the countershaft assembly until it is aligned properly and retightening the nuts.

The mounting is as rigid as if the assembly were held to the ceiling by a number of lagscrews. If necessary, the countershaft can be mounted at an angle to the ceiling timbers instead of crosswise. Where no obstructions are in the way, the assembled countershaft

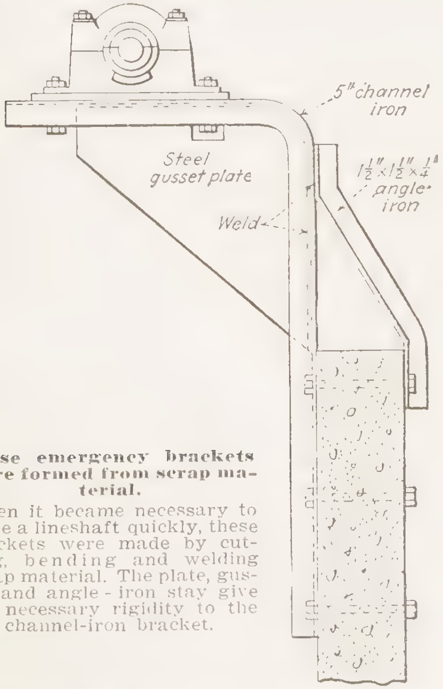
can be moved a considerable distance in the direction in which the joints run.

The stringers as well as the beam should be cut long enough to allow the countershaft to be shifted crosswise of the joist by the distance of one space, which will ordinarily be from 10 to 14 in., and the plates should be so placed as to allow as much as possible of this distance to be utilized for adjustment. In the illustration it will be noted that the countershaft has been shoved about as far to the right as possible, but it can still be moved 6 or 8 in. to the left.

Jena, Germany. HENRY SIMON.

Emergency Bracket for Mounting Lineshaft on Pit Wall

While engaged in some plant extension work, I had occasion to change the location of a lineshaft from a position in front of a concrete pit wall to a position



These emergency brackets were formed from scrap material.

When it became necessary to move a lineshaft quickly, these brackets were made by cutting, bending and welding scrap material. The plate, gusset and angle-iron stay give the necessary rigidity to the channel-iron bracket.

directly over the edge of the pit and about 1 ft. above the wall. There being no wall brackets available, it was necessary to construct something that could be fastened to the wall and at the same time support the shaft.

After looking over the material on hand it was decided that a suitable bracket could be constructed from a number of short pieces of 5-in. channel iron for which we had no other use. How this was done with the aid of a cutting and welding outfit is shown in the accompanying sketch. The pieces of channel iron, which were 4 ft. long, were heated and a short right-angle bend made about 1 ft. from the end with the web of the channel on the inside of the bend. A triangular piece of steel plate was then cut and welded inside the bend, as shown, to form a gusset plate and support.

A short length of 1½x1½x¼-in. angle iron was offset into the shape shown in the sketch and welded to the back of the channel to serve as a back stay.

The bracket was then attached to the wall with bolts going all the way through, one of them also holding the angle iron in place. Four more brackets were made in a similar manner and bolted in place. Effort was made to see that the tops of the brackets were as near in line as possible. The bearing blocks, which were of the self-aligning type, were then placed on the bracket and the shaft was put in place and lined up. Holes for the blocks were then laid off in the channel bracket with the blocks in place and drilled through the channel. When these holes were located, a recess or hole was burned in the gusset plate as shown, to take the nut of a ⅝-in. bolt for holding the blocks in place.

By this means in a comparatively short time it was possible to change the lineshaft location without waiting until we could send for special type brackets. Also these brackets were made from what was practically scrap material.

MAURICE C. COCKSHOTT.

Arcadia, Calif.

Supporting Double Row of Shafts From Building Column

Recently in a visit to an industrial plant, the writer had the good fortune to observe the erection of two lines of shafting in a steel building where the construction presented unusual difficulties. This was a steel and glass, single-story building that was being changed from dead storage purposes to a machine room.

The building had a row of columns of Bethlehem H-beams down the center and a clear floor space of 60 ft. on each side. The columns were joined about 16 ft. from the floor by the 12-in., 31-lb. steel I-beams *A* and *B*, shown in the accompanying sketch. These beams were riveted to short sections of angles or brackets which, in turn, were riveted to the columns. This construction was amply strong enough for its original purpose and also was able to carry a reasonable amount of additional weight.

The plan used in fitting up the building for production was to arrange the machinery in a double row

down the center of the building with a row of machinery on each side of the column. The machines were thus compactly placed and close to the only feasible location for suspending an overhead structure to support the lineshafts. This left a large part of the floor space in the two bays available for other work. The layout included a single length of 300 ft. of lineshaft and an equal length spaced off into several smaller group drives for some machines.

The method of suspension used was rugged and simple. Its basic unit was a short length of 12-in., 31-lb. I-beam, *C*, bolted to the pair of longitudinal beams *A* and *B*. This short beam *C* was placed against

Using cantilever support for a double row of line-shafting.

When a building is not planned for production it is frequently necessary to use ingenious methods for supporting lineshafting. Here short, cross I-beams *C* are fastened to the pair of longitudinal I-beams *A* and *B*, and a row of shafts suspended from each end. These shafts serve two rows of machinery. The motors are mounted on wooden sleepers supported on the top of *A* and *B*. Another row of shaft hangers is attached to the cross beams *C* at the left end, although they are not shown in this drawing.

the side of the H-column and bolted to each side of the lower flanges of *A* and *B*. The beam *C* was thus suspended by the bolts. It would have been better practice to rest them on top of the longitudinal beams and have the bolts serve only for holding the beams in position, but other structural features of the building prevented this. Also, there would have been some disadvantage in this case from raising the shafting higher.

Instead of bolting the hangers to the stub beams *C*, as might have been done, a pair of timbers or stringers was run the full length of the building on each side of

the H-column and bolted to C. The hangers were then bolted to the stringers. Some of the advantages of this plan included reduced likelihood of breaking the cast-iron hangers if rough hangers were bolted to the steel flanges of the I-beams, the ability to space the hangers where desired instead of mounting on the column centers, easier erection, and so on.

The driving motors were placed on top of the steel I-beams A and B on wooden sleepers positioned to suit the drives.

This method of support has much to commend it. The single rows of shafts on each side of the column form a balanced cantilever suspension that adds but little stress to the building structure. There is nothing in the construction which would be in the way of cranes, should these be installed later. This construction is not expensive, in that there are few holes to drill in the permanent structure. Also, the layout is economical of light and floor space.

Plant Superintendent,
Morgan & Wilcox Mfg. Co.,
Middletown, N. Y.
DONALD A. HAMPSON.

Supporting Lineshafts in Mill-Type Building on Standard Angle-Iron Groundwork

Where the buildings of an industrial plant are of a uniform type many economies result from the establishment of a standard form of construction and installation of lineshafts. Two of the main advantages are that the men know exactly how the work is to

This form of standardized construction of groundwork for supporting lineshafting in mill-type buildings is used in one large industrial plant.

be done and so can go ahead with less supervision; also when it is necessary to make a change in the location of a shaft practically all the material is re-usable without additional fabrication.

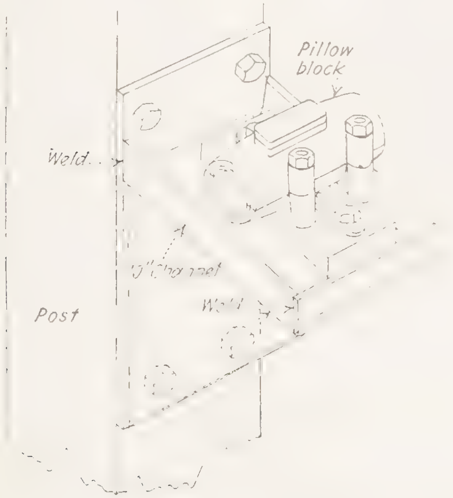
The standardized groundwork used by the master mechanic in one large industrial plant is shown in the accompanying sketch. As may be seen from the draw-

ing, this consists practically altogether of standard angle irons which are laid in pairs to take the feet of the hangers. These footings are supported on other angles which are bent so that they may be fastened to the beam construction by lagscrews. To give the rails or footings additional support a few long lagscrews extend from between the rails to the ceiling beams, as shown. These extra lagscrews are placed near a hanger and on the opposite side from the angle-iron cross-piece supporting the rails.

This master mechanic, also, has the feet of the hangers planed to give them a more firm and true footing against the angle-iron rails.

Method of Welding Up Steel Post Bracket for Pillow Block

When it is necessary to support lineshafting from wood or steel columns and cast-iron brackets are not available, a very solid and effective bracket can be



These post brackets for pillow blocks were made up from a piece of channel and three steel plates welded together.

made out of a piece of heavy channel iron and several pieces of steel plate. A method of doing this is shown in the accompanying sketch.

The piece of channel must be wide enough to carry the size of pillow block on the inside or web of the channel and at least 2 or 3 in. longer than the block.

The bracket is made by welding two triangular pieces of ⅜-in. steel plate to the bottom of the channel and

also to a piece of ⅜-in. plate of rectangular shape which is attached by bolts or lagscrews to the column, as is shown in the accompanying sketch. The front of the channel has a piece of lighter gage plate welded across it, which forms, with the sides of the channel and the back plate, a reservoir to retain any oil which leaks out of the bearing. Holes are cut in the web of the channel, so that the pillow block may be bolted down. Surplus oil is removed through a drain which consists of a short nipple with a pipe cap. The nipple can be welded on or a hole bored through the web and tapped.

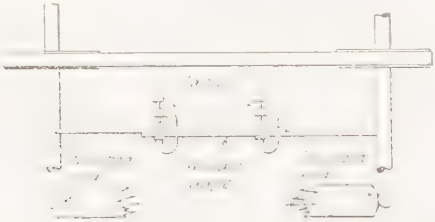
M. C. COCKSHOTT.

Hollywood, Calif.

Easily Constructed Gage for Aligning Shafts

In this book appears an interesting item by Maurice C. Cockshott, entitled "An Easy Method of Aligning Parallel Shafts." I have a method that I believe is better for certain conditions, particularly where the end of the shafting is difficult of access, and for quickly checking the alignment. This method does not require any careful measuring or marking by use of a carpenter's try-square.

The equipment required can be quickly put together in any plant. It consists of two pieces of light, slender but stiff, wooden strips and two light clamps, as shown in the accompanying sketch. With a gage like this, clamped together at a length equal to the distance



The construction and method of using a light wooden gage for checking alignment of parallel shafts is shown here.

between the shafts at one point, it is a simple matter to check the shafts at other points and learn whether or not they are parallel. If the shafts need aligning the gage will touch only at the points of minimum distance; but if the shafts are parallel, the gage will "just touch" at both ends at every place of measurement. If one end of the gage is V-notched to fit over the shaft so that it will not slip off and the opposite end rounded, the gage can be handled more easily.

Wooden gages are far superior to a cord because wood does not stretch or shorten according to the tension. Also, a light wooden stick can be handled with ease and certainty. It is even better than a steel tape,

in that it is easier to get the exact distances between the shafts.

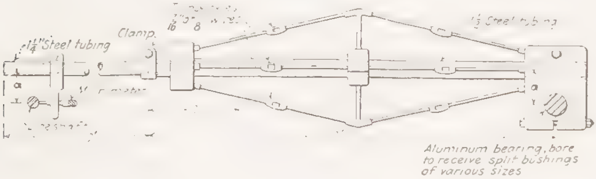
In almost any plant where much shafting is used, it is worth while to make a gage of this kind to keep on hand for use as a permanent tool. When fitted together with a tongue-and-groove joint the two pieces can be adjusted more quickly than without such a joint. However, two plain sticks will serve the purpose very well in an emergency.

W. F. S.

Newark, N. J.

Checking Parallel Alignment of Machines With the Lineshaft

Recently, I had occasion in connection with the installation of a battery of broad drop hammers, each driven by two belts from pulleys at each end of the hammer shaft, to devise some method whereby the alignment of the shafts of the hammer could be made absolutely parallel with the lineshaft. To do this the special gage



This device was used to check the distance between the ends of the shafts of broad drop hammers with the lineshaft, to secure perfect alignment.

The bearing at the right is bushed to fit the shaft of the broad drop hammer. The distance to the lineshaft is then measured exactly by the micrometer. The equipment is then moved to the other end of the shaft and the operation repeated. The difference in the micrometer readings shows how much the shafts are out of alignment.

shown in the accompanying sketch was constructed. This consists primarily of a brace and two pieces of steel tubing, one of which will slide inside the other but still has a close enough fit so that it will not allow any side motion. A clamp permits fastening the two tubes together in any position.

The piece of 1½-in. tubing is 10 ft. long and the piece of 1¼-in. steel tubing, which fits inside of it, is 12 ft. long. There should be a minimum of 2 ft. overlap of the two tubes. When extended to full length, this device may be used to check the alignment of shafts about 20 ft. apart, or it may be shortened up to about 10½ ft. as a minimum distance. These lengths may, of course, be made to fit any special conditions although probably the length indicated above would be the maximum for convenience in handling.

The brace consists of three aluminum castings and four wires or braces with turnbuckles in them. The four-armed spider in the center of the brace may be made either from an aluminum casting, or built up by welding. The ends of the brace were made from aluminum castings, as shown. The large casting at the right is made to clamp around the piece of 1½-in. steel tubing; the bearing which is at right-angles to the steel tubing is bored out to a larger diameter than any of the shafts on the broad drop hammers. Hammer shafts of different diameters were taken care of by using various sizes of split bushings. When in use this bearing is clamped onto one end of the shaft of the hammer.

The casting on the other end of the device holds an inside micrometer, as shown, and is moved along on the tubing until close to the lineshaft and then clamped. It is then possible to make a careful adjustment and measurement of this distance. Additional adjustments for distance may be made by loosening the clamp in the center and sliding the 1¼-in. tubing in the larger tubing.

After taking measurements at one end, the device is then moved to the other end of the hammer shaft and the operation repeated. The difference in the readings of the micrometer shows the amount that the shafts are out of alignment. After the machine is straightened around, the alignment is again checked in the same way. This is repeated until there is no change in the micrometer readings.

W. W. NICHOLS.

Mechanical Engineer,
D. P. Brown & Co.,
Detroit, Mich.

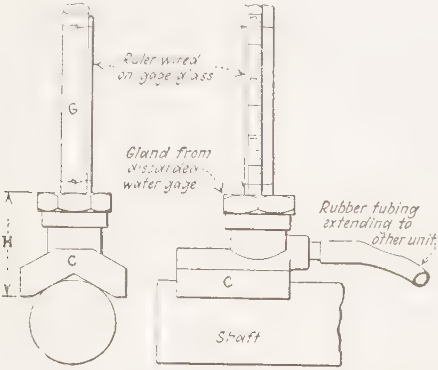
Water Gage for Leveling Line Shafts

On one occasion we were confronted with the task of lining up a shaft that passed through two brick walls, and this prompted us to make the leveling set shown in the accompanying drawing. As in practically all old buildings, the floors had settled unevenly and carried the lineshaft with them. The work was made more difficult because the 30 ft. between the two walls was a sort of dark well so occupied as to make this section of the shaft virtually inaccessible at the point we needed.

This one job, and the fact that we often had shaft leveling to do, induced us to construct a leveling set that would be independent of hand levels, and yet could be used with them when desirable. We made this as a "water level" outfit and first joined the two gages by 60 ft. of tubing; since then we have used as much as 150 ft. of tubing on some jobs.

The cost was low because picked-up parts were used for everything but the bases and the tubing. A simple pattern was made for the base *C* and two of them were cast in gray iron. It would have been better to use brass, but this iron set has worked out very well in practice.

The castings were planed off on the lower flat side and the V cut in on both pieces at the same time to insure that they were made the same size. The upper round riser was turned and threaded in an engine lathe and to this was fitted the gland from a discarded water glass; the pair of glands answered for the set. Two sections of old gage glasses *G* were cut off, the sharp ends smoothed, and then thoroughly cleaned. These were clamped upright by tightening the gland nuts.



A pair of these shop-made water gages was used to level a shaft extending through two brick walls.

The side outlets were drilled and tapped for ¼-in. pipe and half of a 3-in. nipple was screwed in each hole. These side holes, of course, joined the holes in which the glasses were set. Rubber tubing was worked over the nipples until securely gripped.

It was necessary to tighten the nuts so that the height *H* was the same on each gage. Two 6-in. rulers were purchased, sawed lengthwise, and all but the narrow beveled edge, which is graduated, was discarded. These strips were wired to the glasses, as shown, to provide the graduation at very little expense or trouble.

With this equipment, it was a very simple operation to place one member of the set on the shaft in the first room and get a reading of the height of the shaft in the third room. This reading showed a difference of 5/16 in. in this case, part of which could have been detected with hand levels, but not so easily or as accurately, unless we had been able to get at the shaft in the intermediate room.

Even in a room with 100 ft. of shaft, all exposed, a water level is a great help. It often happens that, after starting to level from one end and adjusting each length of shaft up or down to the other end, it is found that the adjustment should have been made either higher or lower at the start because of some belt condition or due to insufficient range in some of

the hangers. By using the set described, an idea of the difference in level between the ends or at any other points may be gained in a few minutes without making any laborious changes that may prove to be wrong. This quick check is very similar to the "preliminary levels" which the surveyor runs over a piece of ground to determine its general characteristics before putting in grade stakes and making other necessary preparations.

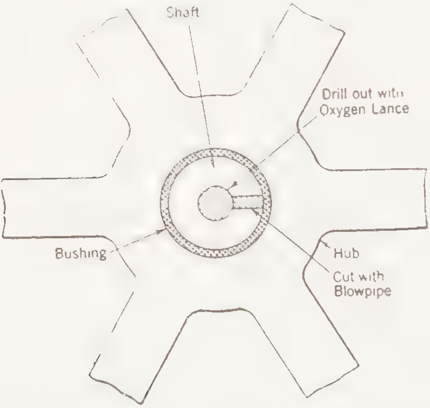
As a suggestion for others who may wish to make such a set, it is best to use large-sized tubing because there is then less water friction and a better chance to get all the air out.

DONALD A. HAMPSON

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

How to Remove Frozen Shaft by Use of Oxygen Lance

One of the most troublesome problems for a shop man is to remove a frozen shaft or crankpin from a gear or pulley with simple equipment. A method of doing this with a cutting blowpipe and an oxygen lance, as recommended by The Linde Air Products Co., New



Method of removing solid pulley or gear when frozen on shaft.

First cut off the shaft at both hubs, and then drill a hole through the center of the shaft with an oxygen lance as shown. The shaft is slotted to the hub of the pulley with the cutting blowpipe and then can be knocked out easily.

York, N. Y., is as follows: An oxygen lance consists of a length of $\frac{1}{8}$- or $\frac{1}{4}$-in. iron pipe and a piece of oxygen hose. This assembly is connected to the oxygen regulator in the usual way.

To cut out a frozen shaft, the first step is to cut off the shaft with the cutting blowpipe near the pulley hub on both sides. The pulley is then placed in a horizontal position so that what is left of the shaft will be vertical, as shown in the accompanying illustration. With a welding blowpipe heat a spot in the center of the shaft end to a bright red heat. Direct the oxygen lance against this hot spot with oxygen at about 10 lb. pressure, passing through the ⅛-in pipe. A hole will be drilled rapidly through the shaft, the pipe in the lance being consumed meanwhile. It may require more than one length of pipe for one deep hole, and the oxygen pressure should be gradually increased with the depth of the hole, to blow the molten metal and slag up out of the hole. The hole should be drilled all the way through the shaft in this manner.

While the metal is still hot, slot the shaft on one side with the cutting blowpipe as shown in the accompanying diagram. This slot can easily be made to the edge of the shaft through the whole length of the shaft section remaining in the hub by starting it on the hot edge of the lance-drilled hole. When the shaft is drilled and slotted in this way, it can easily be knocked out. If it still sticks, however, extend the slot from the hole to the further edge.

Repairing Worn Shaft Under Loose Clutch Pulley

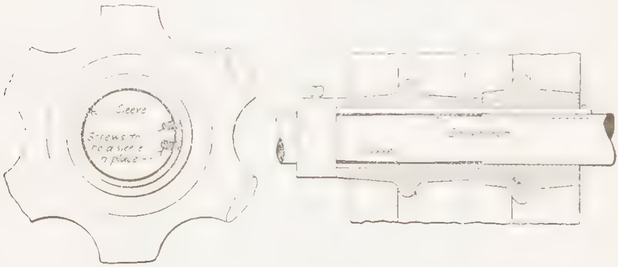
One of the most inconvenient repairs to make on a lineshaft is building up the worn spot caused by a loose clutch pulley. Frequent practice in such cases is to cut out a section of shaft, but this is expensive and inconvenient as well. One method of making a repair of this nature, as reported to H. L. Weber, Master Mechanic, Louisville Woolen Mills, Louisville, Ky., is shown in the accompanying illustration.

In this plant a $2\frac{11}{16}$ in. shaft was worn at a loose clutch pulley to $2\frac{3}{8}$ in. under one edge of the pulley and $2\frac{1}{2}$ in. under the other. The clutch would no longer hold and could not be kept cool when running idle. The installation of a new piece of shafting seemed to be the only remedy. However, renewal of the shaft would have cost about $50 for material, required 26 hr. labor and cause at least 31 hr. production loss in the 20 per cent of the mill in which production was dependent upon this mainshaft.

After considerable study, the repair was made as follows: The high spots on this worn section of the shaft were filed down and a piece of $2\frac{1}{2}$-in., extra-heavy pipe $7\frac{1}{2}$ in. long was turned down to $2\frac{3}{4}$ in. outside diameter and then split on one side only with a hacksaw. Three ¼-in screw holes were drilled and countersunk on each side of the saw cut. The pipe was then slipped and driven over the shaft to the worn place, clamped tightly and the shaft drilled and tapped

to receive the screws which hold the pipe tightly in place, as shown in the accompanying illustration.

When this was done, the pipe just touched the shaft at the high spots on the $2\frac{1}{2}$ in. diameter section, but left an open space between the pipe and shaft at the $2\frac{3}{8}$ in. section and intervening spots. The ends of the pipe were temporarily filled with putty to form a mold, and a thin mixture of Smooth-On No. 1 and Smooth-On No. 3 were poured into the crack left by the hacksaw. The pipe sleeve was tapped slightly with the hammer



A piece of extra-heavy pipe was turned down and slotted to fit over the worn spot on the lineshaft. It was then screwed to the shaft and the void between the sleeve and the shaft filled with Smooth-On Cement.

during the pouring so that the mixture would completely fill the void.

The inside of the clutch pulley bearing which had worn conical, and tapered to the center, was bored and bushed to the new diameter, $2\frac{3}{4}$ in., and slipped over the pipe sleeve. The repair was allowed to stand until the next morning to give the mixture time to harden and form a substantial support for the pipe sleeve. When put into service the clutch operated satisfactorily.

The entire cost of this repair was about \$3 for material, labor 10 hr., and approximately 10 hr. of production loss on the 20 per cent of the mill which was dependent upon this clutch for its power.

Simple Device for Removing Pinions or Pulleys From a Shaft

A simple device which I have found to be very handy for removing pinions or pulleys from a shaft is shown in the accompanying illustration. To make this puller, bore a hole lengthwise of the center through a piece of 3-in. shafting, 8 in. long, and tap it for a standard $1\frac{1}{2}$-in. bolt. Make the $1\frac{1}{2}$-in. bolt 22 in. long pointed on one end and square on the other. Thread this bolt for practically its entire length and screw it into the piece of shafting. The pointed end of the bolt should be

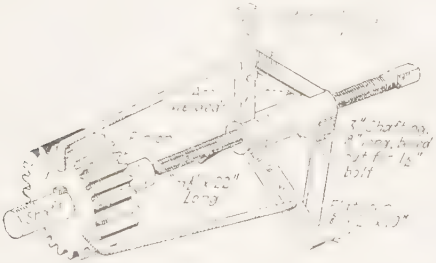
just sharp enough not to slip out of the shaft center when the puller is in use.

Three pieces of flat iron, ⅝ in. by 2 in. by 10 in., should be welded at right angles to the shafting, as shown, spacing them 120 deg. apart. These pieces should be welded very securely to the shaft as the usefulness of the puller depends on the strength of the welded joints.

Three pieces of flat iron, ⅝ by 1¼ in. by 8 in., should be used as braces, with one end welded to the shafting and the other end to the horizontal 10-in. pieces. These braces must have their ends cut at an angle so that they will make a good fit and can be neatly welded.

Four holes 1 in. in diameter, for the puller hooks, should be drilled approximately 2 in. apart in the 10-in. arms.

The puller hooks consist of three pieces of ⅞-in. round iron, 22 in. long. Bend these at right angles, 2 in. from each end, so that one end can be hooked into



A gear or pulley is removed from its shaft by screwing in the threaded bolt.

the puller arm and the other end back of the pulley or gear to be removed from the shaft. Three sets of hooks should be made, so that on small gears or pulleys the set will be easier to handle. We use three sets of hooks of the following lengths: 8 in., 14 in., and 20 in. All of these are made of ⅞-in. round stock.

In operation the puller is placed against the gear or pulley to be removed, with the hooks inserted in the holes in the puller arms which will bring them as close as possible to the face of the pulley. The other ends of the hooks should be placed behind the gear or pulley. The 1½-in. bolt may then be screwed against the shaft with a wrench, thus forcing the gear or pulley off the shaft.

The puller described above was made for heavy service and weighs about 35 lb. Lighter material could be used, but the above specifications are recommended. As an example of what this puller can do fan spiders have been removed from a 2$\frac{15}{16}$-in. shaft when they fitted so tightly that we had to use a 36-in. wrench on

the bolt, with a piece of 2-in. pipe slipped over the handle for extra leverage.

If the bolt should become jammed and hard to move, run it through a threading machine. Also tap out the threads in the shafting, so as to keep the puller working freely at all times. Different hooks may readily be made to fit special gears or pulleys and can always be reused.

WM. B. CONE.

Chief Electrician,
Shevlin Hixon Co.,
Bend, Ore.

Where and Why Lineshafts Break in Service

Transmission shafting carrying driving or driven pulleys or rope sheaves as a general rule break just inside the hub of the pulley. The reason for this is not hard to understand. A shaft that carries pulleys and transmits power is subjected to two main forces tending to disrupt it. The principal one of these forces is that of twisting, caused by the turning of the shaft. The result of this force is called the twisting moment; and if we assume a length of shaft between any two hangers and with no pulleys thereon, this twisting moment will be the only force to which the shaft is subjected, neglecting the weight of the shaft. The load on the shaft will be that due to the amount of horsepower that is being transmitted.

If now we consider a length of the shaft between two hangers, but which has a pulley located on it at some place, we have a different condition. Forgetting for the moment that the shaft revolves, we can consider the shaft as a beam loaded at some point with a concentrated load, the pulley in this case being the load. This condition tends to deflect the shaft just as in the case of a beam, or in other words to create a bending moment. If the pulley or sheave is midway between the bearings this bending moment will be a maximum. As the location of the pulley moves nearer either hanger the bending moment decreases.

A shaft in motion carrying pulleys is, therefore, subjected to a combined twisting and bending moment which is greatest in the hub of the pulley, and it is for this reason that shafts break at this place. If the belt is put on so tightly that the shaft is deflected, as is often the case, there will be an additional bending moment caused by this condition.

The fact that shafts tend to break in the pulley hubs, rather than elsewhere, is an advantage in one way since they usually give warning before they disrupt completely, and thus avoid wrecking the transmission equipment or the machinery that is beneath. The breaks are not as a rule sudden and complete, but start at the outer surface and progress gradually across the shaft. In the meantime there will be indications of trouble. The belt may tend to run to one side of the pulley; the adjacent bearing may heat; the shaft just outside the hub and sometimes the hub itself may heat; the pulley

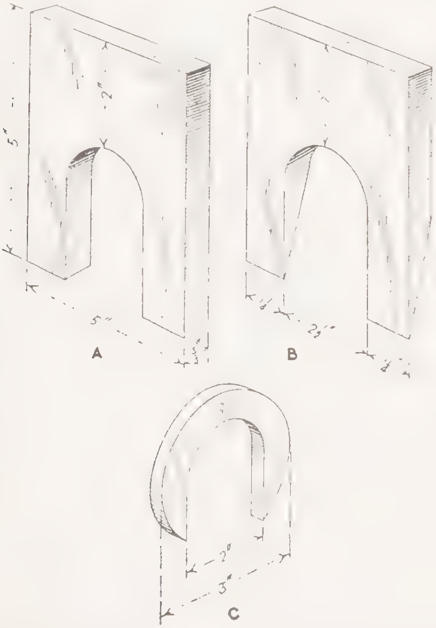
may wobble; or there may be a grating sound heard at times. Any one of these indications should be investigated as soon as possible after being noticed, as it may mean a broken shaft.

The remedy for such trouble is to use shafting of ample size for the load and locate the pulleys as closely to the hangers as possible; or better still, place a hanger on each side of the pulley.

Lawrence, Mass. JOHN A. COLLINS, JR.

Wedges for Driving Pinion from Shaft

The accompanying sketches show a set of wedges which I have used for driving off motor pinions where the space between the bearing and the pinion is too small to permit the use of a puller or a key-drift. These



The set of wedges, A and B, are used to drive off motor pinions when they are very close to the bearing. The washer, C, is used to reinforce paper pulleys before using a puller or these wedges.

wedges consist of a flat steel plate with an opening as shown. A set consists of several wedges of the form shown as *A* and one tapering wedge *B* used for starting. All of these are of the same thickness. The tapered wedge *B* is driven in the full distance, removed, a straight wedge of the form *A* inserted, and the wedge *B*

again driven in. Or, if preferred, a puller may be used after the pinion is started.

The wedges for use on a 25-hp. motor were made from a piece of steel 5 in. square and ¾ in. thick. This set is shown in the sketch. Wedges of proportionate size would be used on smaller shafts. With these wedges, the pinion on a 25-hp. motor was removed in a few minutes, although it had for several hours resisted all efforts to remove it by other means.

Another difficult problem is the removal of very tight paper pulleys by a puller, as the strain may loosen the fibrous body of the pulley from the hub. By using a slotted washer *C* against the end of the hub of the pulley to bring it flush with the edge, the strain is taken off the body of the pulley and transmitted to the hub. With this washer, either the wedges or a puller may be used on paper pulleys.

E. E. G. Roberts.

Southern Manganese Corp.,
Anniston, Ala.

Aligning Parallel Shafts

One method which I have found convenient for aligning parallel shafts such as a lineshaft and a countershaft or jackshaft, is shown in the accompanying sketch. This device consists of a length of 2-in. by 2-in. lumber, which has been dressed on all four sides for

This easily-made device is used to check alignment of countershafts or jackshafts.

The short length of angle iron gives a firm footing against the main shaft. The difference in the distances to the two ends of the parallel shafts indicates the amount of misalignment.

convenience in handling and marking, and a short length of 2-in. by 2-in. angle iron, fastened to it to form a T as shown. The inner faces of the angle iron must be free from rough rust spots or dirt which would prevent it from fitting snugly against the shaft. Also, the stick should be mounted so that it is at right angles with the angle of the iron.

Wherever it is possible to get at the ends of the countershaft or jackshaft, the angle iron is laid in place against the mainshaft as shown in the sketch, and the distance from the center or circumference of the countershaft or jackshaft is marked on the stick. This is repeated at the other end of the shaft and the distance between the two marks indicates the amount that the shaft is out of parallel. Correction for misalignment can be made with the adjusting screws at either or both ends of the shaft and the alignment again checked.

If the end of the countershaft or jackshaft is inaccessible, such as when it is in a bearing, the angle iron is laid against the main shaft as before, but the stick is placed across the top of the countershaft or jackshaft. The base of a carpenter's tri-square is placed on the stick with the blade extending downward and pushed along until the blade comes in contact with the circumference of the countershaft. The position of the blade of the square is then marked on the stick and this line is compared with a similar line obtained at the other end of the countershaft. The difference between these lines indicates how much it is out of alignment.

Before checking these alignments the countershaft should, of course, be levelled. It is preferable to make these tests as near to the ends of the countershaft as possible, so as to get the greatest length possible between the checks.

This method has many advantages over attempting to use a string or laying a stick across the top of the two shafts and measuring with a tri-square. The piece of angle iron need be only a few inches long and it is usually possible to find enough space on the main shaft free from pulleys to make these measurements.

Hollywood, Calif. MAURICE C. COCKSHOTT.

LUBRICATION

Lubrication Insured by Control Devices and Warning Signal

An interesting combination of control devices and warning signal has been installed by the Power River Co., Vancouver, Can., to prevent failure of the lubricating system on a large generator, and to prevent overheating of the generator thrust bearing. Upon failure of the main oil pump, a reserve pump is immediately started and a signal is sounded. The signal is also sounded when the thrust bearing overheats.

The oil pump, which is regularly used during the operation of the generator, is driven through gearing from the generator shaft. An independent motor-driven oil pump is also provided, with equipment for hand starting. Should the geared pump fail to operate, the motor-driven pump will go into service automatically.

This is accomplished by a General Electric pressure switch which is installed in the discharge side of the geared oil pump. With this arrangement, if the pressure of the geared pump drops, the pressure switch closes a magnetic switch, starting the motor-driven pump and sounding an alarm which operates on a 125-volt a.c. circuit.

The second pump, however, operates until normal conditions are restored and pressure is again being delivered by the geared pump, whereupon the contacts of the pressure switch open and the motor-driven pump is shut down.

The thrust-bearing on the generator is equipped with a Tycos thermostat alarm control that operates a 125-volt, direct-current industrial signal when the temperature rises above a pre-determined maximum.

Owing to the fact that the contacts of the thermostat are designed for operation only in low voltage circuits it was necessary to employ a bell ringing transformer to supply the current for closing the small relay that connects the alarm signal to the 125-volt d.c. circuit. This simple system of control devices insures reliable and efficient lubrication at all times.

Oil Rings for Emergency and Permanent Installations

In an emergency a very effective oil ring may be made from a long spiral spring. The spring should be small in diameter, but heavy enough to maintain an approximately circular shape when it is looped around the shaft and the ends hooked together. If a suitable spring is not available one may be quickly formed on the lathe, by wrapping No. 18 piano wire around a ½-in. mandrel.

For a more permanent installation one may use a length of Baldwin roller chain of a small pitch. The pitch should not be more than ⅜ in. for use on a 3-in. shaft, and should be in proportion for smaller or larger shafts.

Such a chain oiler will carry a large amount of oil, compared to other types, the chain links acting as pockets to hold the oil.

Changing Method of Feed Solved Lubrication Problem

Many times the modernization of the lubrication of old equipment is difficult because the construction of the bearings, unless altered in some way, does not permit using a different lubricant than the machine was originally designed to use. This is particularly true, in many instances, where it is desired to change from a grease to an oil lubricant. Often the old bearing is not tight enough to retain the oil. This is sometimes overcome by using a bottle, wick, or drop oiler which feeds

a definite amount of oil to the bearing continuously. In addition, care must be exercised to see that the oil grooves are cut properly to distribute the lubricant.

An interesting problem, however, arose recently in connection with the modification of the lubrication system for a crusher which was originally built for grease lubrication. The grease, which was placed in a deep chamber reservoir, was supposed to flow down to the bearings as needed. It was found, however, that the heavy grease used caked and failed to flow. Oil ran through too quickly, as this was a loose-fitting bearing. Also, a lighter grease ran through too rapidly.

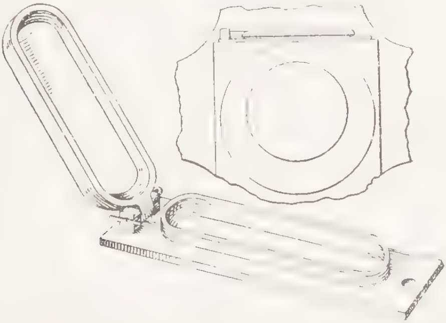
The difficulty was overcome by installing a plug with a much smaller opening at the bottom of the grease chamber and using a grease with a light body. This small opening restricted the flow of the light grease to the amount required for the bearing. The grease was too light in consistency to cake. Plugs with openings of different diameters were tried until one was found which reduced the flow of the light grease to the proper amount required for the bearing.

F. E. G.

Chicago, Ill.

Handy Oil Well Cover Permits Easy Access to Bearing

In the plant where the writer formerly had a large number of motors in his care, it was necessary to have ready access to the oil rings when the motors were started up after a regular 24-hr. shutdown during cold weather, for the oil at such times generally congealed to the consistency of vaseline. Under these conditions



This oil well cover enables the operator to gain quick access to the oil ring of a motor bearing.

the oil rings will not turn when the motors are started, and the bearings will often heat up locally before the oil is thin enough to allow the rings to revolve.

Most motor manufacturers equip their motors with stamped steel covers, which are fastened with screws

over the top of the oil well. On the other hand, most of the men who started the motors in our plant were rated only a little higher in rank than common laborers; so the oil rings used to be neglected, for these men seldom had a screwdriver to remove the oil well cover so that they could start the oil rings turning. We decided to devise an oil well cover that would keep the dust out of the bearing and yet allow ready access to the bearing, for inspection purposes. The result of our efforts to devise a cover is shown in the accompanying illustration. We had no facilities for making these covers of cast iron, but there were a number of large, junked motor bearings on hand, so we made the covers of white metal. These bearings were melted in an ordinary stove and cast in sand molds at the electrical shop.

A number of our Crocker Wheeler motors had broken oil well covers; so we used these as patterns. None of our electricians was experienced in foundry work, but as they had a general idea of how castings are made, they soon turned out beautiful castings that required very little finishing. The white metal proved to be nearly as hard as cast iron and, after the covers were installed, no bearing troubles were experienced on the motors so equipped.

Possibly some readers may believe that it is cheaper and more satisfactory to purchase oil well covers from the manufacturer, but the writer is of the opinion that it would be rather difficult to secure covers of this kind for all types of motors. This is especially true if one has some 30 or 40 different sizes of motors produced by a dozen different companies. I have recently been informed that one of the motor manufacturers is now equipping his motors with a cover very similar to the one just described, with the exception that the covers are made of stamped steel and a spring is used to keep the covers closed when the bearing is not being inspected.

CHAS. A. PETERSON.

Fairbanks, Alaska.

Recommendations for Lubrication of Ball Bearings

Ideal lubrication for a ball bearing consists of an oil circulating constantly in an ample, but not too ample, volume and with only slight pressure. "Ideal" is used advisedly, because an ideal is something that can be attained only with the greatest difficulty and trouble, if at all, which is exactly the case with the above method of lubricating ball bearings.

Five main difficulties, however, lie in the way of oil lubrication: (1) Heat is generated by the churning of the oil at speeds as low as 300-400 r.p.m. unless an overflow is provided to maintain a proper level; this churning and heating increases proportionately with the depth of the oil and the rate of speed. (2) Oil,

being a liquid, is hard to retain in a housing. This is especially true because under the churning action of the moving balls the oil is vaporized and floats out of the housing. (3) Owing to vaporization and other factors, oil requires frequent renewal. (4) when shafts are not revolving, the force of gravity draws the oil to the bottom of the housing, leaving the bearing dry and exposed to rust; filling housings full enough to cover the balls at all times results in the above-mentioned churning and heating. (5) Oil is more expensive than grease.

From this it will be seen that, however "ideal" proper oil lubrication might be, it is almost impossible to attain it within reasonable bounds of expense and under the average service conditions.

With the object of simplifying the lubrication problem and obtaining a practical, satisfactory lubricant the Fafnir Bearing Co. have in the past few years devoted considerable time to lubrication experiments. As the result of these tests the general use of grease has been recommended at all speeds and temperatures and for all sizes of bearings; this does not mean that on some applications oil will not give as satisfactory service, but that grease on these applications will give equal if not better service with less trouble.

This recommendation is based on the following points: (1) Grease of the proper consistency does not work out of the housing. (2) Enclosure design is simplified. (3) Grease applied with a modern type of gun is kept perfectly clean. (4) Grease does not need as frequent renewals. (5) Grease does not sink to the bottom of the closure when the bearing is idle. (6) Suitable greases are easy to obtain. (7) Inasmuch as grease tends to fill the space between shaft and housing, it assists materially in keeping out dirt. (8) At high speeds the rise in bearing temperature is less than with oil.

The essential properties of a suitable ball bearing grease are: (a) Consistency a little stiffer than vaseline; generally No. 2 or 3 as graded by automobile grease manufacturers. This is important, as a grease of this consistency is stiff enough not to churn at high speeds, yet soft enough not to dry. (b) No abrasive or body-giving matter, such as talc, graphite, or pumice. (c) Mineral base—not vegetable or animal grease.

For normal speeds, 300 to 1,500 r.p.m., grease renewal once a year is ample. Under any conditions the most frequent renewal is every three months. At time of renewal the housing should be filled up until some of the old grease works out, which can be wiped off. This is also a good time to note the quality of the grease last used and to see whether it has hardened. The tendency of grease to dry out is what really determines the frequency of lubrication.

Greases that will meet the above mentioned specifications have been giving many of our customers satisfactory service for years, and we believe have greatly simplified bearing lubrication. Users of ball bearings

are invited to send samples of their greases to the Fafnir Bearing Co.'s laboratory for analysis and approval. This service is rendered for the good of the ball bearing industry and has no strings attached.

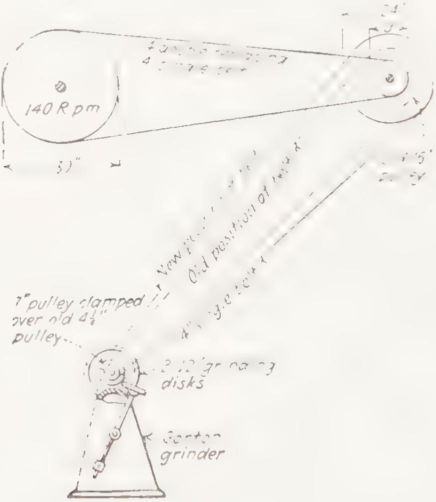
Chief Engineer,
The Fafnir Bearing Co.,
New Britain, Conn.

H. R. REYNOLDS.

MECHANICAL POWER TRANSMISSION

Increasing Pulley Diameters Made Drive Pull Load

In ordinary belt drives, when improperly designed, an almost unbelievable amount of power is lost needlessly. The following example covers an unsatisfactory belt drive on a Gorton grinder and shows how it was corrected by simple changes.



Overcoming the faults in a belt drive.

The old drive would not pull the load but when the pulley diameters were increased the drive delivered all the power necessary without slippage. Increasing pulley diameters, which increases the belt speed, is a simple method of improving a belt drive and also relieves the tension of the belt and the pressure on the bearings.

This type of grinder has a chuck at each end of the spindle with abrasive rings clamped in them and a swinging table on which the work is blocked while passing across the face of the grinding rings. Both thrust and radial loads on the bearings are heavy at times. However, the grinder had babbitt bearings of

ample size which were in excellent physical condition. The report on the drive was that "it never seemed to have power enough, although it did when first put in."

The layout of the drive is shown in the drawing. Good, 4-in. single belts were in use, applied very tight. A 30-in. pulley was used on the lineshaft; this was the maximum with the hangers. From there, the belt drove to a 9-in. pulley on the countershaft, which carried a 16-in. driving pulley leading the second 4-in. belt to the 4¼-in. cast-iron pulley on the spindle of the machine. This last driven pulley was considerably worn from the belt slippage. The theoretical speed of the grinding wheels was 1,784 r.p.m. but this was not being realized by several hundred revolutions when the load was on.

An investigation showed that the belt in the first reduction should have been of greater capacity than that in the second reduction but, instead, they were of the same size, with the added inconsistency of the first belt's slower speed, which reduced its transmitting power over 40 per cent. To remedy this, a 4-in. double belt was installed in place of the first single belt.

Obviously, the fault with the second drive was that the pulleys were of too small diameter. This was corrected by putting a 24-in. pulley on the countershaft and a 7-in. one on the machine spindle; this was the maximum clearance at those respective locations. Because of the shrunk-on members at each end of the grinder spindle, the new pulley was made in halves and bolted over the old one. This new cast-iron pulley was given a $\frac{1}{16}$-in. crown or taper for 1 in. at each edge, leaving 3 in. of straight surface in the center.

These changes were so successful in transmitting full power to the machine that both grinding wheels may now be loaded to capacity at the same time without any slippage.

Donald A. Hampson.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Overcoming Shock and Moisture on Board Mill Drive

Most paper mills have several machines that operate under conditions which may be termed "hard drives." Moisture, continuous operation under heavy loads, and starting under full load give a type of service which is very trying on the driving elements.

One of the drives which gave considerable trouble at the plant of the Chicago Coated Board & Paper Co. was on the first-press drive of a board mill. One of the helper-drive belts slips more or less, according to the thickness of the board. This results in severe shocks and vibration being transmitted back into the speed reducer which has its slow-speed shaft direct connected through a flexible coupling to the main shaft of the helper drive.

The speed reducer is belt driven from an engine-driven lineshaft. This drive had always given trouble because the speed reducer was too closely rated for the work it had to do and would overheat during the five days of continuous operation from Monday morning until Saturday morning.

To overcome the difficulties in connection with this drive a new Cleveland Worm & Gear Co. 100-hp., 8-to-1 reduction ratio, worm speed reducer was installed by the Beloit Iron Works. Dodge-Timken tapered roller bearing pillow blocks were used on the short shaft at the left which carries the main driving pulley. This shaft is direct-connected to the worm shaft through a Bartlett-Hayward flexible coupling. A Moore & White variable-speed drive on the engine governor permits a variation of speed from 80 to 450 r.p.m. on the worm shaft. Because of the moisture, Test-special rubber belting, manufactured by New York Belting & Packing Co., is used for all belts.

The old worm reducer had been in use about five years. This reducer had a rating of 75 hp. which was not sufficient for the continuous operation. It was not discarded when removed but was placed on the first-press drive of a smaller board machine, where it operates very satisfactorily. A companion mill was changed over to be driven by similar equipment. During the nine months that these two new drives have been in operation they have given no trouble. This is largely due to the ample rating of the unit, the much larger radiating surface of the gear case, and the ample oil supply which does not heat so quickly.

Another source of considerable trouble was in the cylinder bearings. Because of the moisture these bearings were difficult to lubricate and keep lubricated.

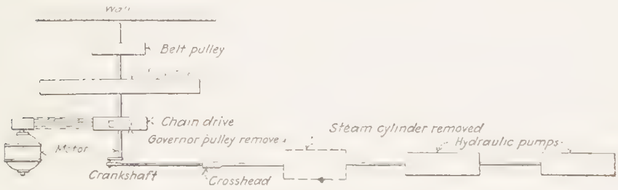
Beginning in 1918, SKF ball-bearing pillow blocks were installed on these cylinder shafts whenever old bearings had to be replaced. Some of these original ball bearings are still in use. However, whenever water gets past the seal the bearing rusts and must soon be replaced. The infrequent replacement of a ball bearing is the matter of only a few minutes, whereas it requires several times as long to replace an old plain bearing.

Connecting-Up Silent Chain to Engine Shaft to Drive Reciprocating Pumps

Problems incidental to changing over from steam engine to motor drive are often complicated by the necessity of using as much of the old equipment as possible to keep the capital investment low. A good example of this was in connection with the substitution of a motor and chain drive for a steam engine at the St. Louis, Mo., plant of the Hydraulic Press Brick Company.

Brick manufactured by this company is formed in special hydraulic presses. The engine used in the

former drive had a single steam cylinder which was located just ahead of the two pumps, as shown in the sketch. The steam cylinder, therefore, drove the pistons in both pumps which provide the hydraulic pressure for operating the brick presses. A flywheel and belt pulley are mounted on a crank shaft. The pulley, in turn, is belted to a lineshaft which drives a system of crushers and conveyors for feeding the press.



Motor and silent chain on engine shaft driving pumps.

Removing the governor pulley provided space for the chain sprocket on the engine shaft. The steam cylinder was removed, as shown in the sketch, but otherwise the connection to the hydraulic pump cylinders is the same reciprocating drive as when the engine was used. This permitted modernizing the drive with a comparatively small outlay.

The problem was to attach the motor to this reciprocating unit and also retain as much of the old equipment as possible. How this was done is shown in the sketch. The governor pulley on the engine shaft was removed to get space for mounting the sprocket for the Morse silent chain drive from the motor. This gave 15 in. in which to center the sprocket between the engine bearing and the flywheel hub.

The 50-hp., 485-r.p.m. motor drives the old engine shaft at 68 r.p.m through a 1½-in. pitch Morse chain, 5½ in. wide. This is a speed reduction of approximately 7 to 1 on 6-ft. centers. The entire drive is housed in a steel case, 9¼ in. wide.

Couplings Used to Compensate for Installation Error in Alignment

Although the principal function of a flexible coupling is to absorb the effects of accidental misalignments in the connection of two shafts, it can be used to compensate for errors in installations. This practice is not recommended because the error may cause greater misalignment than the coupling is designed to compensate for and still give good life and service. However, in case of emergency it may be necessary to sacrifice coupling life to prevent an interruption of service.

Such was the case in connection with the rearrangement of a paper mill drive. One paper manufacturer had spent several thousand dollars and considerable time in installing a new paper machine. When con-

necting up the new drive for this and the other machines the entire plant was shut down about ten days.

Plans were made to finish the job one night and start the entire plant the next morning. Later at night, when ready to connect the engine to a jack-shaft from which the necessary auxiliaries were driven, it was found that the engine and auxiliary shaft were so badly out of line that the belts would not stay on their pulleys. It would have required several days to have made the necessary changes.

Although, as stated, the principal function of flexible couplings is to handle accidental misalignments, this was a case where it was of the utmost importance to get the machines running and to keep them running even temporarily; therefore a flexible coupling was installed between two sections of the jack-shaft. One section of the shaft was lined up with the engine and the other section with the auxiliary.

This type of service is extremely hard on the coupling and an extra set of couplings, and perhaps a duplicate coupling, should be ordered at once to be on hand for emergency repairs. In such a case the coupling serves as a universal joint. If another flexible coupling had been available, two couplings could have been used to somewhat better advantage in that each would have taken half of the misalignment. The continuance of such a condition is not recommended but in this case the cost from the continued idleness of the plant would have purchased several bearings.

E. D. F.

Chicago, Ill.

Short Center Drive Prevents Pulley Wear Due to Slip of Dusty Belt

Belts which operate under very dusty conditions must be maintained under sufficient tension or have a large enough arc of contact on the small pulley to prevent slippage; otherwise the dusty belt will cause excessive wear on the pulley faces. The action is similar in this case to an endless abrasive polishing belt.

One of the common methods of overcoming this slippage is to use the gravity idler in preference to a high belt tension. In addition, the belt selected must be pliable, tough and have sufficient strength to withstand particularly hard service for a belt.

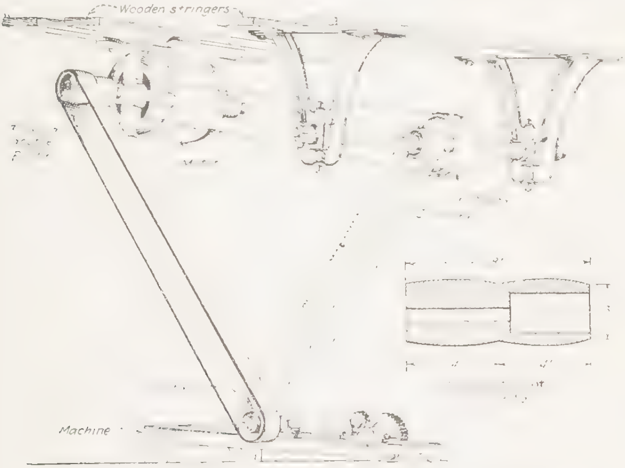
The G. F. Wright Steel & Wire Co., Worcester, Mass., has a 14-inch double Wabeco (Warren Belting Company) leather belt installed under very dusty conditions in a hard drive. This drive has been operating satisfactorily over the Pulmax (Bird Machine Co.) gravity idler for a number of years with an average amount of attention.

Also, a composition pulley is used on the motor to further help reduce the slippage. With the high reduction ratio and short centers an extremely flexible belt is necessary.

When purchasing a belt for any type of hard drive and particularly where much of the severe service is due to the surrounding conditions, such as dust which cannot be prevented, it is especially necessary to consider quality, because life and probable maintenance cost are of paramount importance to assure a low annual belt cost.

Obtaining Half-Speed Drive for Special Work

Although many machines and their drives are designed for a single speed, it is often desirable to obtain a special speed, either higher or lower, for certain kinds of work. Such was the problem in one plant where a machine was used about three weeks out of the month on one line of production and the remaining week on a different product, which was processed at



A special countershaft arrangement for obtaining a half-speed drive.

During ordinary operation the motor is belted directly to the machine. For half-speed operation a special belt is placed from the extended end of the motor pulley to the countershaft. The original driving belt is taken from the pulley and attached to the small cone pulley on the countershaft.

approximately half the standard machine speed. This machine was connected by a 3½-in. belt and a 2-hp. constant-speed motor mounted on the ceiling.

A two-speed drive was obtained by means of an extended pulley and a countershaft mounted a few feet away from the motor. The original motor pulley was 3 in. in diameter with a 4-in. face. A special extended pulley was made from a piece of 3-in. steel shafting about 8 in. long, which was bored out at one end to

fit the motor shaft and the outside of which was turned to make two 3-in. pulleys attached solidly, end to end, with a slight crown turned on each. To decrease the weight on the overhanging end the outer end of the pulley was bored out for about 4 in. to give a ⅜-in. shell on the extension. The pulley was fastened to the motor shaft with a setscrew and key. A countershaft was then erected on the ceiling about 30 in. from, and parallel to, the motor shaft. This countershaft carried a step-cone pulley; one step was 3 in. in diameter, the same as the motor pulley, and the other twice this diameter.

For ordinary operation the belt is extended from the pulley next to the motor down to the machine. When half speed is wanted, the motor belt is placed on the large pulley of the countershaft, which is supported by adjustable drop hangers so that the countershaft can be removed and replaced easily.

The countershaft is so placed that the smaller pulley is in direct line with the pulley on the machine and at such a distance that the same belt can be used to drive from the countershaft to the machine as is used from the motor down to the machine.

The short belt used to drive the countershaft is kept by the machine operator who is held responsible for it. The change-over requires only about 15 or 20 min. A similar plan can be used if it is desired to increase the machine speed, or obtain any other ratio of change, by an appropriate arrangement of driving and driven pulleys on this countershaft.

E. D. F.

South Milwaukee, Wis.

Substituting a Long-Center Chain Drive for Bevel Gears and Shaft

The problem of connecting two parallel shafts slightly more than 10 ft. apart by a silent-chain drive was solved in an interesting manner in connection with a printing-press installation. The original drive of each of four sextuple printing presses at the plant of *The Milwaukee Journal* was from the motor to the jackshaft, which in turn drove six vertical shafts, each connected to a horizontal shaft through bevel gears. Each of these four presses was driven by a 100-hp. motor.

The shaft-driven equipment, as originally installed, was not satisfactory because of excessive friction and high maintenance cost, due to shaft and gear breakage. This was due partly to the peculiar construction of the drive and partly to the lack of headroom for suspending the motor.

Sometime ago this arrangement of vertical shafts and gears was replaced with a chain drive, which has proved satisfactory on the first four press installations and plans are under way for equipping companion presses in a similar manner.

The present drive is by means of a 1.2-in. pitch

Morse silent-chain belt 10 in. wide. Four drives of this type have replaced the vertical shafts with their bevel gears. The chain operates on 128-in. centers and has a total length of about 26 ft. The driving jack-shaft from the motor is underneath the floor and operates at 325 r.p.m. The driven shaft, overhead, which drives the presses previously operated by the vertical shafts and gears, operates at 300 r.p.m. The lower sprocket has 47 teeth and the upper sprocket 51 teeth, which give a chain speed of 1,525 f.p.m. By adopting this chain, three sets of gears have been eliminated on each drive, or a total of 24 gears for the four presses.

Because this was a vertical drive, which is one of the most difficult to operate successfully, due to the fact that any slack in the chain will tend to cause it to hang free from the lower sprocket, it was necessary to install an adjustable idler with a 33-tooth sprocket. This was placed on the tight side of the drive, as a steel building column is directly behind the slack side of the chain, thus preventing the use of the idler at that point. The idler was necessary to keep the vertical chain tight, and also because the presses are frequently stopped suddenly when the stop button is pushed by a pressman and with the idler so placed it prevents whip in the chain.

Engineers ordinarily hesitate to adopt a chain for a drive of this type, not only because it is vertical, but also because of the chain whip resulting from sudden stopping. It was only after a close study of the installation that the new arrangement was recommended. The operation is much smoother, practically noiseless, and the drive consumes less power than the previous installation. In addition, less than 5 per cent as much oil and grease as were previously necessary are required for lubrication, and one less man is required for the maintenance of the press.

Consulting Engineer,
Chicago, Ill.

EARL C. MOSS.

Emergency Speed Reducer Built From Auto Steering Gear

Industrial operating men who are convenient to mill supply houses and the branch offices of various manufacturers can usually be supplied without a great deal of inconvenience with miscellaneous pieces of equipment that they need.

Many plants that are operating away from the larger industrial centers, however, sometimes have more difficulty in obtaining parts in an emergency and the exercise of considerable ingenuity may be required to provide a satisfactory substitute.

One problem which we faced may be of interest to other men in case of a similar emergency. A small pump was to be driven by a fractional-horsepower

motor. The motor was rated at 1,760 r.p.m and the speed required for the pump was about 200 r.p.m. A belt drive could not be used because the space was too small and the location otherwise unsuited to it. It was obvious that a small reduction gear unit would do the work very well, but none was to be had on short notice in this immediate locality.

Finally the worm and worm wheel of an automobile steering gear were thought of. A visit to an auto wrecking shop disclosed the gear ratio of one such device was 8:1. This was mounted on a plank in line with the motor to make a direct-connected drive. A piece of rubber hose, in the emergency, served as a flexible coupling between the motor shaft and the worm shaft. The low speed, approximately 220 r.p.m., was taken off the worm gear shaft which extended at a right angle to the gear unit. The entire assembly operated very satisfactorily and economically solved our emergency problem.

W. L. STEVENS.

New Westminster, B. C., Can.

Driving Double-Purpose Blower at Two Speeds

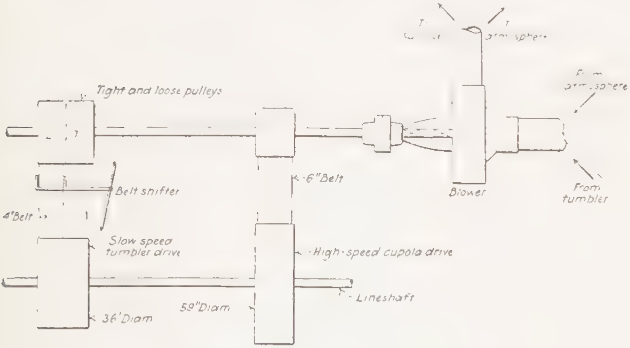
Two tumbling barrels and a blower in the foundry of a New York manufacturer of supplies and machinery for the woodworking industry are driven in an interesting way, as may be seen by referring to the accompanying drawing. All three units are located so that they can be driven from a secondary shaft which is belted to a lineshaft that extends through the wall from the machine shop. The tumbling barrels are driven from tight-and-loose pulleys on the secondary shaft; these are not included in the sketch.

The blower supplies air for a 5-ton cupola and is also used as an exhauster for the tumbling barrels by driving at a slower speed than for the cupola. Ordinarily, a foundry has a smaller blower which is used to exhaust from the tumblers. Thus the arrangement used here combines the work which ordinarily requires two blowers. Inasmuch as the cupola is used after 2:00 p.m. and the tumblers are emptied by noon, there is no conflict of demands.

The arrangement of the two-speed belt drive is shown by the drawing, which is a plan view of the layout with the shaft distances shortened for compactness. The lineshaft carries two large, wooden driving pulleys. The secondary driven shaft is direct-connected to the blower by a flexible coupling; thus the blower runs at shaft speed whenever the driven shaft is operating.

When driving the blower as an exhauster, a 4-in. belt is used from the 36-in. pulley on the lineshaft to the tight-and-loose set of pulleys shown. These pulleys enable the helper to cut off the blower when the tumblers or cupola are not in use. When the tumblers are in use the 4-in. belt is shifted onto the tight pulley

and the 6-in. or high-speed drive belt is slipped off its pulleys and caught on a belt perch. In the afternoon when the blast is needed for the cupola the 4-in. or low-speed drive belt is shifted to the loose pulley and the 6-in. belt is replaced on its pulleys. The belts are again changed back the next morning for the tumbler and slow-speed exhauster drive.



Two-speed drive for blower.

When exhausting from the tumbling barrels the blower is driven at slow speed from the 36-in. pulley on the lineshaft through the tight-and-loose pulleys. This 4-in. belt is shifted to the loose pulley and the 6-in. belt placed on the 59-in. pulley to drive the blower for the cupola.

Branches in both inlet and outlet pipes to and from the fan, with a shut-off gate in each, direct the flow of air as desired. For exhausting, the gate from the tumblers and the outlet gate to the atmosphere are opened. For the blast, these gates are closed and the other two opened. A double-purpose blower is thus secured by a simple shifting of the drive.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

DONALD A. HAMPSON.

Variable-Speed Transmission Versus Variable-Speed Motor

Variable-speed drive and control for assembly conveyors and other equipment which it is desirable to operate over a range of speeds, are ordinarily obtained either by using a variable-speed transmission or a variable-speed motor. Conveyors usually travel at a very low speed and any additional high reduction between the motor and the conveyor is obtained by means of suitable gear reduction units which give a fixed reduction ratio. The experience of the Hupp Motor

Car Corporation, Detroit, Mich., and the comparative cost figures should be of interest to other concerns with similar power-transmission and variable-speed problems.

This company has six style O-E Reeves variable-speed transmissions (Reeves Pulley Co., Columbus, Ind.) in operation at the present time. Assembly conveyors which are operated from the Reeves transmissions range from 200 to 300 ft. in length. The chassis-assembly conveyors, three in number, are typical of all these drives. Each is 244 ft. long and is driven at speeds of 3 to 12 f.p.m. in conveying the chassis through the various assembly operations. In the operation of these conveyor lines smooth control and increment of speed with close regulation are required over a wide range.

Power is supplied to each of the chassis-assembly conveyors from a constant-speed, 3-hp., 1,200 r.p.m. induction motor which is connected to a variable-speed transmission and a gear reduction unit. The latter has a fixed ratio of 95:1 and the variable-speed unit gives a smooth variation in a 4:1 ratio. Conveyor chain speeds from 3 to 12 f.p.m. are readily available.

The use of a variable-speed induction motor would, in this plant, be the only practical alternative for obtaining suitable variation in conveyor speed.

Three such motors are used at the Hupmobile plant for driving three final-assembly conveyors. They have proved much less satisfactory in fineness of regulation and in dependability of operation. These motors are equipped with elaborate control equipment, but are capable of only a 2:1 speed variation which is obtained in only nine steps from the highest to the lowest. Small increments in speed are not possible.

Tabulations that have been made render it easily possible to compare the annual fixed costs for the variable-speed transmission unit with those for a variable-speed motor which, with suitable reduction gears, would give a somewhat similar result.

The use of such a variable-speed motor and gear unit would involve annual fixed charges of $71.42, considering only depreciation and average interest at 6 per cent figured over a 10-yr. period. The Reeves drive actually in use, when analyzed in the same way, shows annual fixed charges of $61.84.

The annual saving is, of course, not large but the operating advantages of the transmission unit are of additional importance. The variable-speed transmissions are, in addition, more dependable in operation and there has been no expenditure for maintenance on them in four years of use.

Furthermore, aside from its less flexible speed control characteristics the variable speed motor must be a much larger unit than the constant-speed motor used with the variable-speed transmission. To deliver 2 hp. at half speed requires a motor capable of developing about 5 hp. at full speed. This results in much lower efficiency at all speeds and loads. At full speed and

developing 3 hp. the efficiency would be 81.5 per cent and at half speed, where the load is 2 hp., the efficiency would be only 41 per cent. A 3-hp. constant-speed motor would have an efficiency of about 85 per cent, varying little with the variation of load between 66 and 100 per cent of motor capacity. The use of the constant-speed motor results in a saving of 1.87 kw. at low speed.

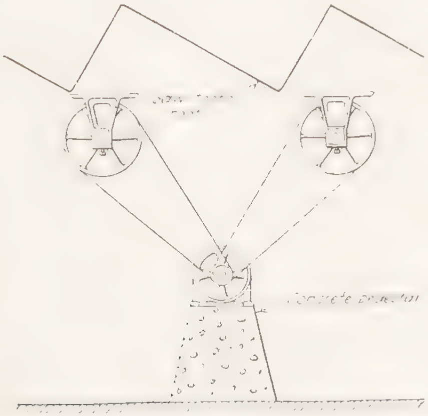
On the other hand, the variable-speed drives can be locked at any speed, thus assuring a set production rate. This is invaluable in maintaining a predetermined production schedule. Close maintenance of a fixed speed has not been possible with the variable-speed motors, as now installed, and their control over conveyor movement has, on the whole, been far less satisfactory than that obtained with the use of the variable-speed transmissions.

PAUL J. ZIEGELBAUR.

Assistant Superintendent of Maintenance,
Hupp Motor Car Corp.,
Detroit, Mich.

Driving Two Shafts From One Motor

The more common method of connecting two lineshafts to be driven by a single motor is to belt the motor to a jackshaft, which is usually placed between



Group drive arrangement for driving two lineshafts from a single motor.

By mounting the motor on the concrete pedestal, it is raised above the floor line, so that it is not likely to be damaged by passing trucks. However, the motor is not too high to be easily accessible.

the two lineshafts, and drive both from it, or to belt the motor to one shaft and drive the other shaft by belt from the first. The first plan requires the erection of an additional jackshaft, while the second method requires that the first shaft be heavy enough to take

the full load, although half of it may be transmitted directly to the second shaft.

The accompanying illustration shows a third method of arranging a single motor drive for a pair of parallel lines of shafting which is used at the Poughkeepsie. N. Y., plant of the DeLaval Separator Co. These shafts are located in a single-story building with saw-tooth roof and the lines of shafting follow the valleys of the roof, with the machine tools aisled off in a similar manner. Each pair of shafts is driven by a single d.c. motor, which is located alongside the main longitudinal aisle at one side of the room and at the end of the shaft. Each motor is mounted on a substantial concrete pillar, as shown in the sketch, which lifts the motor above the floor dust and high enough to be safely out of the way of passing traffic. The pulleys are higher than the head of a tall man, but still not too high to be convenient for giving any necessary attention to the motor. Testing, oiling and inspection can be carried out by standing on a light portable platform without the risk and time loss that accompany work from a ladder.

It is usually considered poor engineering to run two belts off the same pulley or to operate belts in such close proximity, chiefly owing to the chance of their fouling. However, no difficulty has been experienced and the belts keep on running safely year after year with not more than an inch between them. One reason for this satisfactory operation is because the heavy driving belts are kept in good condition and so do not run wavy or deviate from a single path of travel.

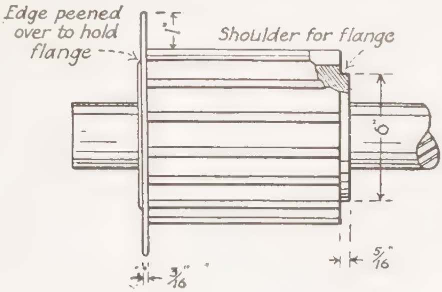
Repairing Worn Flange on Pinion of Chain Drive

In a plant built in 1902 the two a.c. generators are supplied from two 220-volt, 200-amp. exciters with Link-Belt silent chain drives, 6 in. wide and 1 in. pitch. Twice in their life of usefulness, the bearings of these exciters have been rebabbitted. The last time the bearings were out, the armature shafts were taken out and the commutators lathe-turned and undercut. However, the principal reason for shopping the equipment was to repair the sprockets. The chains used depend upon flanges at the ends of the sprockets to keep them from running off. These flanges were so badly worn and low that the chains would occasionally jump up on them with the fluctuations of the load. There was not enough slack in the chain to take out a pair of links and the adjustment take-up had gone the limit of the rails.

The method of repair is shown by the accompanying drawing. New flanges, which were made higher than the old ones—actually double the height above the teeth—were put on. These flanges were cut from sheet steel, bored to fit a turned shoulder at each end of the sprocket, and were peened fast; a slight countersink

in the flange, and a high shoulder enabled this to be done in a very secure manner. The outside diameter of the flanges was turned in place and the corners were well rounded over. One machine was repaired first and, as it proved to be very satisfactory, a duplicate job was done on the second.

This is a good example of the long service that it is possible to obtain from a chain drive. The service to which these chains are subjected imposes an intermittent load on them, yet no one connected with the plant recalls any chain breakage. One of the chains is still



The old flanges, which had worn too low to retain the silent chains on the sprockets, were replaced by these disks.

in good running condition, the other is to be renewed, and both sprockets are as serviceable as new, although the tips of the teeth are rounded instead of clean cut as they were at first.

DONALD A. HAMPSON.

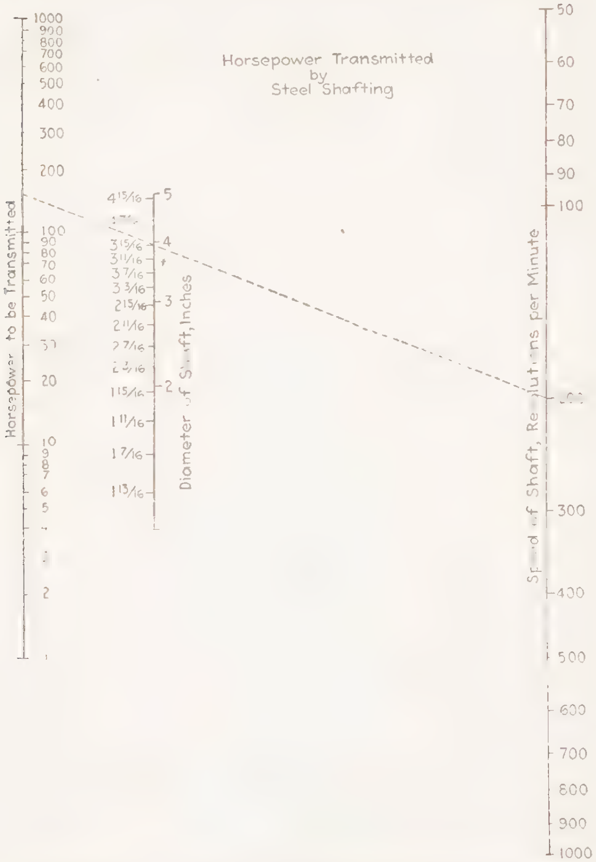
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Estimating Horsepower Transmitted by Lineshafting

In laying out line-shaft installations it is frequently desirable to make computations for different speeds and different sizes of shafting. Although this may be computed in each case, it is easier to determine the various capacities and ratings of different sizes of shafts at various speeds by the use of the accompanying chart. This chart was designed according to the following formula:

Diameter $= \sqrt[3]{[(\text{hp.} \times 80) \div \text{r.p.m.}]}$. This is a standard formula for determining the size of a lineshaft and applies only for standard construction where hangers are spaced on 8-ft. centers. The constant, 80, takes into account the installation of an ordinary number of pulleys driving machines and spaced within the 8-ft. centers. The main driving pulley should, of course, be on a section of shaft with the hangers placed closer together.

With this chart, horsepower transmitted, diameter of the shaft in inches, or speed of the shaft, may be determined if any two of the factors are known.



This chart is used for determining the horsepower transmitted by steel lineshafting when spaced on 8-ft. centers.

The method of using this chart is best explained in connection with an example, such as determining the diameter of a shaft which will transmit 150 hp. at 200 r.p.m. To determine this, place the straight-edge on 200 r.p.m. on the right-hand scale and on 150 hp. on the left-hand scale. Read the value on the center scale at the intersection with the straight-edge. A $3\frac{15}{16}$-in. steel shafting may be used under the given conditions.

The scale on the left, horsepower to be transmitted, has values ranging from 1 hp. to 1,000 hp. The center scale, diameter of shaft in inches, is graduated in the more common sizes of shafts used. The right-hand

scale gives the speed of the shaft in revolutions per minute, over a range of 50 r.p.m. to 1,000 r.p.m.

The chart is used as follows: Place a straight-edge across the chart on the two known values, such as the horsepower and speed; and the intersection of the straight-edge and the center scale will give the size of shaft to use for the given conditions. Obviously, if any two values are known the third may be found by placing the straight-edge on the two known qualities. The intersection of the straight-edge and the third scale is the unknown quantity.

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Chart for Determining Power Transmitted by Friction Wheels

Horsepower Transmitted by friction disks or wheels of different composition when used against cast-iron surfaces may be quickly determined by means of the accompanying chart. Only two simple operations are required in using this chart. How the horsepower transmitted is determined is easily explained by an example. For instance, if the width of the friction face of a wheel is 3 in., the mean diameter 20 in., and if it turns at 1,000 r.p.m., what horsepower will be transmitted by a leather fiber wheel bearing on a cast-iron wheel?

The two dotted lines drawn across the chart show how this example is solved. First, extend a straight line through the 3 (the width of the face), in column *A* and the 20 (mean diameter of the wheel), in column *B*, and locate the point of intersection with column *C*. From that point of intersection, extend another straight line over to 1,000 (r.p.m.), in column *E*; the intersection of this line with column *D* gives the answer as 42.8 hp.

Between columns *C* and *D* are shown other combinations such as tarred fiber on cast iron, straw fiber on cast iron, and so on. When such combinations are used, find the point of intersection with column *D* in the same manner as before and then measure upward from the intersection the distance indicated by the corresponding arrows for the particular computation; the top point thus located in column *D* gives the horsepower that will be transmitted, using the combination mentioned. In other words, the length of the arrow indicates the amount to be subtracted in each case because the other friction surfaces have lower transmitting capacity than leather fiber on cast iron. Thus, for example, tarred fiber on cast iron will transmit 33 hp., straw fiber on cast iron, 18 hp., wood on cast iron, 10.8 hp., leather on cast iron, 9.6 hp., and a cork composition on cast iron, 4.8 hp. These figures are readily checked on the chart by measuring upward the distances indicated.

The term "mean diameter" is used in column *B*, as

HORSEPOWER TRANSMITTED BY FRICTION WHEELS

With this chart the horsepower transmitted by friction disks of various composition, bearing on cast iron, may be easily determined.

In the example shown, a leather fiber friction faced wheel 3 in. wide (*A*) and 20 in. in diameter (*B*) operating at 1,000 r.p.m. will deliver (*D*) 42.8 hp. To get the horsepower transmitted by wheels of other composition, bearing on cast iron, proceed as with leather fiber but measure up (subtract) from the intersection on (*D*) the length of the arrow indicated opposite each composition.

in the case of bevel or miter wheels, the mid-diameter should be used rather than either extreme.

This chart is based on the following rule: To find the horsepower that may be transmitted by spur, miter or bevel friction drives, multiply the effective width of the face in inches by the mean diameter of the wheel in inches, then by the number of revolutions per minute made by the wheel and then by 0.00071. The result is the horsepower transmitted by a leather fiber wheel bearing on a cast-iron wheel. Where other compositions are employed in place of leather fiber use the following constants instead of 0.00071:

Tarred fiber on cast iron.......	0.00055
Straw fiber on cast iron.......	0.00030
Wood on cast iron	0.00018
Leather on cast iron...........	0.00016
Cork product on cast iron......	0.00008

This chart may also be used in the reverse order; that is, where the horsepower, mean diameter, and revolutions are known, and it is desired to determine the proper width of face, begin at the right and the width will be found in column *A*. Correspondingly, when any three factors are known, the fourth may quickly be found.

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Safe Method of Lining Transmission Guards While Operating

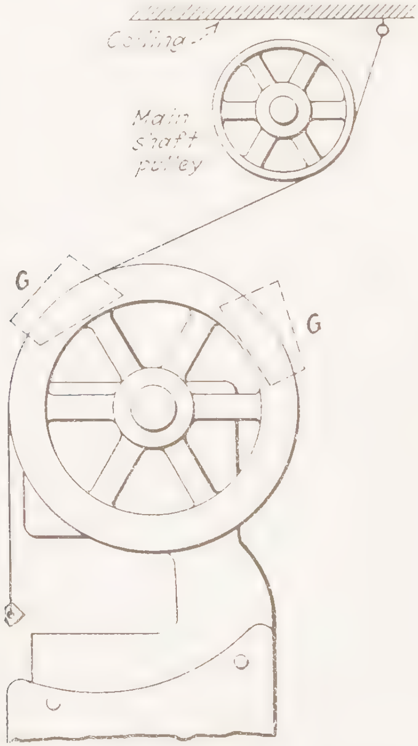
Every millwright has had to do jobs after working hours because of the risk or impossibility of working around moving transmission equipment. Even the measurement of belt lengths by use of a tape over the pulleys is fraught with danger and difficulties. The accompanying drawing shows a method of doing, without risk and in a most simple manner, a job in which moving pulleys figure.

Two guards were to be applied to the belt and flywheel, which also served as the pulley, of some punch presses and attached at the points *G* and *G*. The guards themselves were of the box type which provides a bell-mouthed opening for the belt and also has sides which completely enclose the pulley and belt on the exposed sides. It is obvious that the only way to set these guards properly is to have the belt or its equivalent in position.

To attach the guard it was necessary, for safety, to have the press idle because of the danger of working around a moving flywheel. With the belt thrown off the flywheel there was no means of lining up the guard. For this reason it had been considered necessary to do the work at night. In order to avoid overtime work on this occasion, the millwright in charge threw off the belt and substituted a line, as shown in the accompanying sketch. The first step was to attach a small

eye to the ceiling above the pulley on the lineshaft. A cord was fastened to this eye and carried over the moving pulley on the lineshaft and on down over the flywheel on the press. A nut on the end of the cord served as a weight to hold it in position. This cord provided him with a true belt line from which he could accurately place his guards, which were secured by angles to the frame of the machine.

Following this same method the whole battery of machines was fitted during working hours. It was



By using this string instead of the belt it was possible to line up the guards during working hours and while the lineshaft was operating.

necessary to have only one machine idle at a time and it was possible in every case to find periods when the machines were idle for other reasons. In addition, the whole job was done better than would have been the case at night, and by a simple, safe method that is applicable to many other jobs around moving pulleys.

It may not be out of place to mention that this incident serves as another illustration of the fact that the most obvious method of handling a job is not always the best method. For this reason a little time spent in planning the work and deciding just how it may be done with the greatest ease and safety, all things considered, will usually be well invested.

This is particularly true in the case of operations or work that ordinarily would mean stopping equipment for a time, or that involve an injury hazard to the workmen, as in this instance. Usually one has but to calculate the value of the output of a machine or group of machines, with the wages of the operators, for even a comparatively short period of time to be convinced of the advisability of avoiding shutdowns as much as possible, when work is to be done on power drive equipment. However, pursuit of this ideal should not be carried to the point where the workmen are exposed to any unusual hazards.

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Flexible Drive Solves Fan Operating Problem

In many cases a satisfactory type of drive for one class of service will not operate so well under different conditions. Probably one of the most severe service conditions for many drives is shock load. Mechanical drive elements that do not provide sufficient flexibility to take care of the shock are not only subjected to the effect of the shock, but pass it on to the bearings. As a result, the mechanical element of the drive either breaks or is hammered to pieces, unless a unit of extra size or strength is provided, or the next weakest link of the drive gives away.

In such cases the inclusion in the drive of a flexible unit that will absorb this shock has solved the transmission problem in a number of instances. For example, a brick plant recently installed a steam engine to drive a large exhaust fan. The engine and fan were connected on close centers by a metallic inflexible drive. Due to the sudden changes in load, the fan would run ahead of the engine at times and then, as the load came on, would tighten up with a snap, with the result that the drive would soon be pounded to pieces. A flexible drive of the Texrope type (Allis-Chalmers Manufacturing Co.) was installed with good results. Sudden load changes are absorbed by the flexible drive with little or no bad effect, it is stated. The change also provided considerable relief for the engine and fan bearings.

In making changes such as this in a drive, care must be exercised to see that flexible units of sufficient size are used and that they are strong enough to absorb the overload due to the shock. This means making an allowance in the rating. Where the shock is severe, it is seldom sufficient to substitute any of the various

types of flexible drive units without providing the necessary overrating.

Still another advantage of flexible drives on fans is their silent operation, which is an important consideration when the fan is located near factory or other offices, in schools, theaters, and so on.

Selecting Worm Gear Speed Reducers of Proper Capacity

The gear speed reducer has become a very important factor in the past few years as a means of stepping down high-speed commercial motors and other prime movers where they are to function with machinery and equipment operating at lower speeds. This same statement applies equally to the spur, worm, and herring-

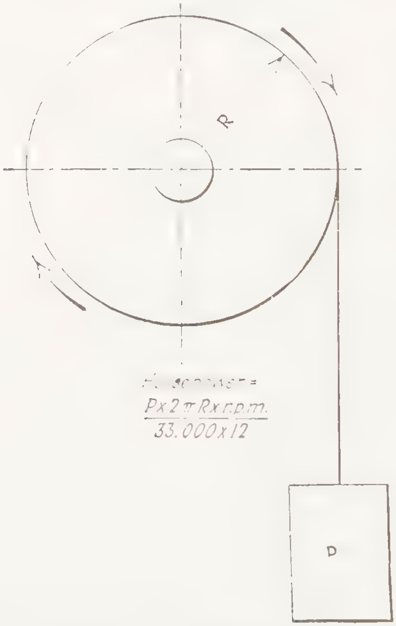


Fig. 1—This diagram is the basis for determining horsepower requirements of speed reducers.

bone gear types of speed reducers, all of which have certain uses for which they are best adapted.

The worm gear speed reducer is suitable for use in installations where the direction of the power drive must be changed at right angles. This article will be confined to a discussion of the worm gear speed reducers with particular attention to how these reducers can be applied in meeting individual speed reduction or

power transmission problems. Basic information giving formulas and a knowledge of the applications of speed reducers to practical problems is important to the executive or engineer, when he has in mind the use of speed reducers in new equipment, or for replacements.

In dealing with worm gear speed reduction problems practically the same information relative to loads, horse-power and torque, is necessary in making the calculations as it required for the spur gear type. It must be remembered that, theoretically, the same horsepower is delivered by the reducing units as is delivered by the prime mover. The speed, however, decreases through the worm reducer, depending upon the reduction ratio used, and the torque or twisting moment correspondingly increases.

It must be borne in mind, also, that worm drives are inherently less efficient than spur gear reducers, and the power delivered to the driven unit will be considerably less than the power received, because of frictional and other losses in the worm drive. Therefore, this factor must be considered in making calculations.

To make a proper selection of the correct size of worm gear reducer to meet a given set of conditions, it is necessary to have a clear understanding of the relation of the various elements involved. Simple formulas show the relation of horsepower, load, and torque, and how to calculate the capacity of worm gear speed reducers required to meet certain conditions. The symbols used in the formulas are as follows:

P = Load in pounds on drum or pulley.
P_1 = Standing load in pounds on worm gear.
$2\pi R$ = Circumference of worm gear (inches).
N = Revolutions per minute (r.p.m.).
T = Torque or twisting moment in inch-pounds.
W = Work done.
$Hp.$ = Horsepower. (33,000 ft.-lb. per min.).

Torque or twisting moment is that force which tends to produce rotation in a shaft or pulley and is equal to the product of the force acting times the length of the lever arm. This is expressed by a formula, $T = P \times R$ (See Fig. 1).

Work done is equal to the product of the force acting on the object, times the distance through which it moves. When D = distance traveled, then $W = P \times D$.

The distance through which the force acts in one revolution is equal to the circumference of the circle, which is $2\pi R$. Work done in one revolution is expressed $W = P \times 2\pi R$ in.-lb. Where the drum or pulley makes more than one revolution the total work done will be, $W = P \times 2\pi R \times N$ in.-lb.

Since 1 hp. is equivalent to 33,000 ft.-lb. per min., the horsepower required to revolve the pulley N times per minute against the weight P will be: $Hp. = (P \times 2\pi R \times N) \div (33{,}000 \times 12)$.

Other useful formulas derived from these equations are as follows:

$$Hp. = (T \times N) \div 63{,}025;$$
$$T = (63{,}025 \times \text{hp.}) \div N;$$
$$T = P \times R;\quad P = T \div R;$$
$$R = T \div P;$$
$$W = 2\pi \times T \times N.$$

In dealing with worm drives it is necessary to take into consideration standing and running loads on the gear teeth. By standing load is meant the back pressure on the gear due to the load on the driven unit while at rest. Thus, Fig. 2, by applying the formula for torque it will be found that the torque necessary to move the load on the driven shaft will require a gear with radius R, but the standing load on the gear will make necessary a gear of larger radius, R_1, on such applications as elevator hoist drives, and the like.

To arrive at the proper radius for the worm gear in cases of this kind it is necessary to calculate standing and running loads, as follows: $P_1 = (P \times R) \div R_1$, but $T = P \times R$, then $P_1 = T \div R_1$ and $R_1 = T \div P_1$. Then R_1 will be the radius of the worm gear strong enough to withstand the standing load.

By using one or more of the above formulas it is possible to solve practically any speed reduction problem which may be presented; some of the methods used are indicated in the simple problems which follow. Let it be borne in mind, however, that in actual practice, the efficiency of both the reducer and the driven machine must be considered, when selecting reducers of the proper size. Some examples of the practical applications of these formulas on worm gear speed reducer problems may be given as follows:

(1) If we have a drum with a radius of 6 in., and a load of 1,000 lb. to be moved, find the torque necessary to move it.

$T = P \times R = 6 \times 1{,}000 = 6{,}000$ in.-lb. torque.

(2) If the drum is to be driven at 1 r.p.m. how much work will be done during this revolution?

$W = 2\pi \times T \times N = 6.28 \times 6{,}000 \times 1 = 37{,}680$ in.-lb.

(3) How much horsepower will be required to drive the above drum at 15 r.p.m.?

$Hp. = (2\pi R \times P \times N) \div (33{,}000 \times 12) = (6.28 \times 1{,}000 \times 15) \div (33{,}000 \times 12) = 1.42$ hp.

(4) If we knew that the torque on the drum shaft was 6,000 in.-lb. and the speed 15 r.p.m., what horsepower would be required to drive it?

$Hp. = (\mathrm{T} \times N) \div 63{,}025 = (6{,}000 \times 15) \div 63{,}025 = 1.42$ hp.

(5) If 1.42 hp. is required to drive this drum at 15 r.p.m., what is the torque in inch-pounds on the center of the drum shaft?

$T = (63{,}025 \times \text{hp.}) \div N = (63{,}025 \times 1.42) \div 15 = 6{,}000$ in.-lb.

(6) If the torque or twisting moment at standing

load on the drum is 6,000 in.-lb. and radius of the drum is 6 in., what is the load on the drum in pounds?

$P = T \div R = 6{,}000 \div 6 = 1{,}000$ lb.

(7) If the torque on this drum is 6,000 in.-lb. and the load on the drum is 1,000 lb., what is the radius of the drum?

$R = T \div P = 6{,}000 \div 1{,}000 = 6$ in. radius or 12 in. diameter.

(8) If the drum radius is 6 in., the load 1,000 lb. on the drum, and the radius of the worm gear is 8 in., what is the standing load on the worm gear?

$P_1 = (P \times R) \div R_1 = (1{,}000 \times 6) \div 8 = 750$ lb.

(9) If the torque on the drum shaft is 6,000 lb. and the standing load on the worm gear is 750 lb., what must be the radius of the worm gear to withstand the load?

$R_1 = T \div P_1 = 6{,}000 \div 750 = 8$ in. radius or 16 in. diameter.

Let us now assume the conditions for a problem and carry the calculation through to the selection of the proper size and type of worm gear reducer to do the work. Assume that we have an elevator whose efficiency is 95 per cent (i.e., the friction loss in bearings, sheaves, and so on equals 5 per cent). The elevator drum or sheave shaft is 18 in. in diameter and is to be driven by a worm gear speed reducer at a speed of 15 r.p.m. The total load to be lifted is 3,548 lb. Speed of the driving motor is 800 r.p.m. The computations are as follows:

$Hp. = (2\pi R \times P \times N) \div (33{,}000 \times 12) = (6.28 \times 9 \times 3{,}548 \times 15) \div (33{,}000 \times 12) = 7.6$ hp.

As the efficiency of the elevator is 95 per cent, the actual hp. required will be: $7.6 \div 0.95 = 8$ hp.

Assume the average efficiency of the worm gear speed reducer as 70 per cent; therefore, the size of motor required will be 8 hp. $\div$ 0.70 = 11.43 hp. (Size of motor required which also indicates the load on the reducer.) The reduction ratio is 800 to 15 or 53.33 to 1.

Manufacturers generally list reducers according to capacities and reduction ratios and with the above information a selection of the proper machine can be easily made. It is necessary, also, to calculate the actual standing load for this particular problem and compare it with the safe standing load listed by the manufacturer, to make sure that the reducer selected will withstand the load. Standing load is determined as follows:

$P_1 = (P \times R) \div R_1 = (3{,}548 \times 9) \div 13.5 = 2{,}365$ lb.

The capacity of the driving unit must always be great enough to compensate for frictional and other losses in the reducing unit and driven unit and to start the load on the driven unit even though the power required while running is much less.

The efficiency of worm gear speed reducers varies considerably, depending upon the following factors, which are listed in the order of their importance:

(a) Helix angle of the worm.
(b) Pitch line speed of the worm.
(c) Materials used in the worm and worm gear.
(d) Nature of lubricant used.

(a) The curves in the accompanying chart (Fig. 3), clearly show the relation of helix angle to efficiency. To use the above efficiency curves it is first necessary to determine the lead or helix angle, as the figures used across the bottom of the curve, Fig. 3, represent degrees. To obtain lead or helix angle use the following formula.

A = Helix angle; L = Lead in inches.
$P.D.$ = Pitch dia. of worm.
$\text{Tan}\ A = L \div P.D.$

Values of Tan A for Helix Angles

Tan A	Deg.	Tan. A	Deg
0.087	5	0.577	30
0.176	10	0.700	35
0.267	15	0.839	40
0.363	20	1.000	45
0.466	25		

The accompanying table gives values for the tangent in steps varying from 5 to 45 deg. which will assist in locating on the efficiency curve the result arrived at by solving the above formula for various leads and pitch diameters of the worm.

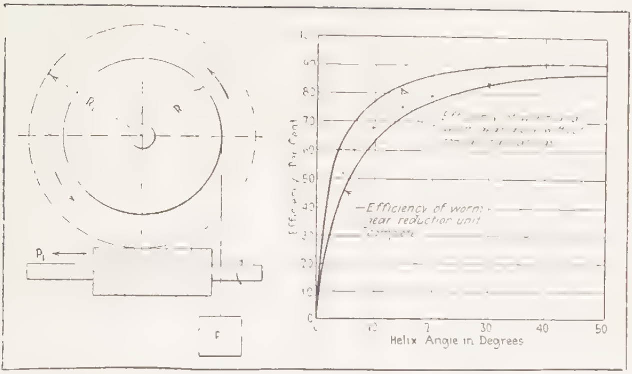
In cases where worm reduction units are operated under heavy loads at comparatively slow speeds the efficiencies will be considerably lower than indicated by the curve. In such cases the efficiency may be increased somewhat by using a heavy grade of lubricant which prevents the oil film from squeezing out and breaking down.

(b) The factor of the pitch-line speed of the worm should be considered in selecting worm reducers, and motors to operate them. Pitch-line speed of worm should preferably stay below 1,000 f.p.m.

(c) Long experience and numerous tests by reducer manufacturers have indicated that the combination of a steel worm and bronze worm gear give good results and high efficiency for continuous service. For intermittent service, the steel worm and semi-steel worm gear have been found very satisfactory.

(d) The influence of the lubricant used on the efficiency is a minor factor, but the highest efficiencies will be maintained by following the recommendations of the manufacturer for lubrication of a given unit.

For certain classes of work such as hoists, inclined conveyors, or where the load must be suspended after



Figs. 2 and 3—Force diagram of worm reducer and worm gear efficiency curves.

The drawing at the left indicates the action of the load on a worm gear and is used in connection with the formulas. The chart at the right shows the relation of the helix angle of the worm to the efficiency. The figures across the bottom of the chart represent the helix angle is determined by using the accompanying formula and table, as described in the text.

the power has been shut off, it is desirable to have worm gear speed reducers which are self-locking, to prevent a reversal of the reducer. Where such reducers are required a worm with a smaller lead is necessary. Such a worm may be calculated as follows:

PD = Pitch diameter of the worm gear in inches.
C = Center distance between shafts of worm and worm gear.
P_1D_1 = Pitch diameter of worm.
H = Cotangent of helix angle of worm.
E = Lead in inches of worm thread.
$P_1D_1 = 2C - PD.$
$H = (\pi \times P_1D_1) \div E.$

For a single-thread worm the lead E equals the distance between threads; for multiple worms, multiply this distance by the number of separate threads. If the angle whose cotangent is equal to H is less than 5 deg. the worm will be self-locking.

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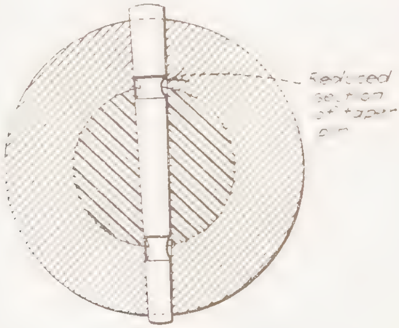
Breaking Pins Protect Drives Against Overloads

Protection against overloads in mechanical drives which may be stopped suddenly is just as necessary as the fuse in electrical circuits. In many cases on belt drives the belt serves as the safety device in that it will slip or run off the pulley if the machine stops sud-

denly. However, if the belt tension is high the possibility of slipping is decreased also, the belt will slip off the pulley more slowly, and some part of the machine may break first. For this reason it is often desirable to place a safety link of some kind in the driving mechanism of the machine. These safety links are usually in the form of breaking pins or shear links, which have a cross-section sufficient to drive ordinary loads, but are weaker than any other part of the drive, so that they will break first and protect gear teeth or other more expensive elements of the drive. The following examples show how these links were used in three instances.



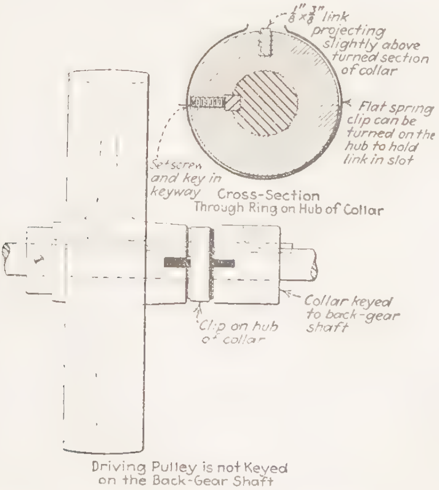
Method of installing a breaking pin in a gear drive. By decreasing the cross-section of this taper pin, which holds a driving gear to its shaft, a safety link is placed in the line of power transmission. This link breaks whenever an overload is thrown on the milling machine. The pin is easily removed.

On each of a battery of duplex milling machines, a box, containing the trip, feed drive, and reverse gears, is suspended from the saddle at its front end. This box is attached by four long screws with the heads counterbored in the saddle of the tableways. This construction is neat and substantial and when assembled nothing but the line where the faces meet shows that it is a two-piece construction. However, the last member in the feed mechanism is a hardened worm that drives the hardened gear through which the splined table-screw passes. This worm is attached to its shaft with a No. 3 taper pin which serves as a breaking pin and, whenever the work jams, the hard worm on the hard shaft cuts the pin off completely. This shop uses belts of such size and under sufficient tension to make them proof against slipping, which makes the feed or drive stronger than the pin.

When the pin is sheared, the table must be removed before the gear box can be taken off to get at the worm and replace the tapered pin. This is a heavy job either with the table stripped or with the fixtures left on,

and it takes two men about 2 hours to replace a broken taper pin.

The master mechanic decided, after a few such experiences, that, while a breaking piece was necessary, it should be located where it was more convenient. The construction was changed so that the breaks now occur at a more accessible gear outside the box, due to the



Details of a safety link in a back-geared drive.
When the work jams this link breaks. The link, which is a piece of ⅛-in. by ⅜-in. steel, fits into a slot on the loose pulley hub and in a collar keyed to the shaft. A flat spring steel clip fits over a neck which is turned down on the end of the collar and holds the safety link in position, as shown in the sketch. An overload breaks the link and leaves the pulley free to turn on the shaft. The operator keeps a supply of extra links on hand and can replace a broken one by slipping the spring clip around, until the gap between the ends is over the slot.

weakening of the No. 3 taper pin which holds this gear to its shaft. Now, all of these milling machines have this one easily accessible spot where the taper pins have a reduced shearing section, as shown in accompanying sketch at top of page, which breaks off when an overload is thrown on the feed.

In another instance the repair man in a factory manufacturing valves and fittings had considerable trouble with threading machines jamming, due to an imperfect casting which would be too heavy for a tap or die to cut; here the threading was done on the unmachined castings.

At the first opportunity this repair man put a breaking piece on one of the machines, but instead of a taper pin he used a small piece of flat steel which was set

half in each of two collars on a mainshaft on the machine. The cross-section of this strip of steel is small enough to allow it to shear off before any damage occurred elsewhere. The plan was very successful and now all these machines are so equipped.

Not long ago the writer saw a multiple semi-automatic filing machine with a simple and effective shear link. This machine was back-geared and the link was placed on the first shaft between the main pulley, which was not keyed to the shaft, and a collar keyed to the shaft, as shown in the sketch at bottom of page. The links were held in position by a circular spring clip of flat steel which was snapped around the hub of the collar. The ends of this clip were open about an inch. Turning the clip on the hub covered the link and held it in the slot or exposed the slot so that the broken link could be removed and the new cne inserted.

In case a file jumped out and caught (as was sometimes the case), the pin broke. Otherwise the operator would have had the trouble of replacing a large belt on an overhead shaft 18 ft. above the floor. The operator of the machine had a supply of these links, which he could replace as quickly as he could replace a file because of the simple arrangement for holding them firmly in place.

Care must be exercised to see that the operators understand and appreciate the value of these links and do not put something in that will not break, which would be the same as replacing a blown fuse with a piece of steel wire. Making it easy to replace the shearing pin or having a supply of such pins convenient, if the operator is to replace those broken, will help to insure their proper use.

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Simple Methods of Quieting Noisy Gears

There are many reasons why gear drives are noisy. They may be made with cast teeth, they may be running at a speed too high for their particular type, they may be meshed too tightly, they may be badly worn or running on shafts that are not parallel. There is a certain amount of noise—small, to be sure—every time a tooth strikes its mate, and this, multiplied by the number of teeth and speed of revolution, builds up the roar that is so nerve racking and so unnecessary.

Recently the noise from a machine in a plant attracted notice. It was impossible for a person standing alongside the machine to be heard, except when shouting. The drive was by a 4-in. belt running at 1,800 f.p.m. from the first shaft through three pairs of gears to the fourth shaft, which turned at 3 r.p.m., a reduction of 160 to 1. Somewhere in those gear trains was the noisy member. The workmen had become used to it, looking on it as a necessary evil, and said the machine had always been noisy.

It sounded like gears too closely meshed and, from the frequency of the pulsations, it was on the first shaft. A request for a flashlight and a chance to investigate showed that the gears were bottoming in the first two trains. They were all under the machine and during the various periods of repair the bearings, which were bolted to the planed undersurface of the frame, had been "socked up tight" with a big wrench, and there they stayed.

With such constructions, it is customary to give the bolt holes $\frac{1}{16}$ in. of play and finally to secure the bearings by the big wrench method after a careful alignment, or else to use dowels. Undoubtedly the builder had had the shafts properly lined up, but evidently the repair crew had trusted to the bolt holes to space the shafts as they ought to be. Being under the machine where he had to lie on his back to work, the repair man had taken the quickest and easiest way, even if the machine and the employees did have to suffer.

Loosening up the first shaft's bearings and blocking it all the way back while the bolts were tightened, a start was made toward correction. Then the second shaft was loosened and moved back half the amount of the first one. The space between the gears could be seen then when the pulley was rotated back and forth. The final procedure was to cut sections of hard maple, which were wedged in between the pairs of bearings at right angles to the grain. This made it sure that they would not come together again, and if they fell out, it would show that some movement had taken place.

Any time that gears under inspection show evidence of rubbing action at the root of the teeth, noise and improper setting may be looked for. In this case it was evident at a glance. When the machine was started up again it ran almost noiselessly.

Gear teeth are so cut that their action is rolling in mesh, not rubbing, and there is everything to lose by not maintaining the correct mesh. Teeth should never bottom. There is purposely cut at the bottom a clearance which is approximately one-tenth of the height of the tooth. When the meshing of a pair of gears maintains this clearance, almost no noise will result from running and the wear of teeth will be reduced to a minimum.

Side clearance is also provided for when the teeth are cut. This amounts to 0.002 or 0.003 in. No easier way of setting gears can be followed than to place a slip of newspaper alongside two of the teeth at the point of tangency. This clearance is readily discernible to the eye if one of the gears is moved back and forth.

One of the most frequent violations of this gear bottoming rule is found in machine shops in connection with lathe change gears. When these gears are changed, there is always a swing gear or one studded in a slot, which is set to make up for differences in diameters, or to connect up the train. Machinists are prone to push these gears up hard as they are tightened; the result is that bearings and teeth get unnecessary wear and

there is a grinding noise set up that should cry aloud to supposedly trained men. Moved apart $\frac{1}{32}$ in, the gears would run quietly and wear would be minimized.

The use of grease and oil may be commended in some cases, but when lubricant is used to cover up or relieve too tight a setting of cut gears, it is wrong practice. A film of lubricant may be needed in most cases, but that film is immediately broken down where no clearances exist.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Decreasing Pulley Wear From Abrasive Dust on Belts

Belts operating in an atmosphere of abrasive dust often grind away the pulley surface, particularly at the crown. Although it is usually considered better practice to run belts with the slack side on top, it may in such cases, be best to drive with the tight side on the top, with a resulting increase in belt and pulley life and efficiency.

Where a considerable amount of dust is flying about, particularly if this is abrasive, if the slack side is at the bottom the belt flap or vibration, which always occurs on the slack side, will tend to shake the dust off the belt and so prevent at least part of it from being carried around the pulleys and worked into the belt to wear away the pulley surface as the belt slips. All of the dust will not be displaced by the flapping, but a good deal of it will be.

When the tight side of a smoothly moving belt is at the bottom it presents an ideal place for dust to settle on. In such cases, the advantages gained by having the slack side on top are easily counterbalanced by the longer belt and pulley life and increased efficiency obtained by running the belt with the slack side on the bottom.

Refacing Surface of Fiber Pulley

One of the early installations of motor drive in an Eastern city was that of a fabric-manufacturing plant that had put in a 125-hp. dynamo, which was driven by a Corliss engine, to furnish power for the motors. They called them "dynamos" exclusively then and rated them by horsepower instead of kilowatts. After running 28 yr., six days a week, it became advisable to turn off the surface of the pulley on this dynamo.

This was one of the familiar paper pulleys used on electrical machines, and it had been on during all this time the dynamo had been used. The 20-in. belt had worn grooves near the edge, as well as wearing the surface somewhat out of round. The pulley was 23x23 in., with 3½-in. bore.

No mandrel was available for turning the pulley;

nor was any bar steel handy large enough from which a soft mandrel could be made. The possibility of making a casting and using it for a mandrel was discussed. Finally the venerable millwright made the suggestion that a stick of hickory in the storage shed could be used for the mandrel.

Accordingly a piece 3 ft. long was cut and roughly shaped with a draw knife. Then carefully drilled ⅝ in. centers were put in each end. These centers were soaped and the stick was turned and fitted as a mandrel. Later the pulley was turned down and recrowned by using this same wooden mandrel.

The tool used was a high-speed steel bit held in an ordinary holder. The slant of the tool holder gave the tool about the proper top angle, or rake, for good cutting. The tool was ground far back underneath, giving it about four times the clearance angle of metal-cutting tools and approaching the included angle of the wood turner's chisels. In general, this keen tool was formed like a regular round-nosed metal-cutting tool or bit. It was set about 3 in. above the center of the fiber pulley. (On a smaller diameter it would not have been so much above the center of the work.) The object was to produce a tool that would cut freely because it was keen and placed at the easiest cutting angle. With a material not possessing the strength and resistance of metal, it is necessary to adopt means that will cut without tearing the fibers.

The tool, at best, cannot be expected to leave a presentable surface. No. 1 sandpaper tacked to a piece of board of considerable width was then used to smooth off the turned surface.

Instead of coating the turned surface with paint or shellac, the manufacturer recommended a finish of belt dressing. This was applied by holding stick dressing against the pulley as it revolved in the lathe. The heat sufficed to spread an ample amount on the pulley. After placing in service, the lapping of the belt very soon imparted to the treated pulley a fine smooth finish quite like that on a new pulley.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

DONALD A. HAMPSON.

Roller Chain Used on Quarter-Turn Drive

Unusual operating conditions sometimes make it necessary to devise unusual drives. An interesting example of this kind may be found in the plant of the I. H. Dexter Co. of Goshen, N. Y.

This concern manufactures flexible shaft couplings consisting of tooth flanged members joined by roller chain of sufficient width to cover, between the side plates, the teeth cut in the periphery of both flanges.

The flanges on the large couplings are faced in a gap-lathe which was assembled in the shop. Because this machine is used but part of the time, nicety of

design was sacrificed to utility and the lathe stands, rugged but inexpensive, a good tool for the purpose.

It is used as a facing lathe only and is fitted with a special cross slide. The power feed is unusual and presents some features of interest. The feed screw runs the full length of the table and has the usual ball crank for hand setting. Power is applied to this outer end from above.

A countershaft runs directly above and at right angles to the end of the screw and the extended cross slide, and advantage was taken of this fact to join the shafts by a chain drive. This is unique in that it connects the shafts at right angles which makes it a quarter-turn chain drive. Roller chain is used and is practicable because of the long centers and the slight flexibility in each link of the chain.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

III

ELECTRICAL

ELECTRICAL

BATTERIES

Proper Method of Cleaning Dirty Storage Battery Boxes

Some very interesting information as to the proper method of cleaning storage battery boxes was given in an issue of *Pullman News*. It seems that the Pullman Company has discontinued the practice of cleaning batteries with water. It was found that the practice of washing out battery boxes at the time batteries are flushed or when an accumulation of foreign matter has collected, is responsible to a large extent for many leaky cells found in service. Such leaky cells are caused by the electrolytic action of the current flowing between adjacent cells or crates and woodwork of the box, to grounds caused by wet and acid-soaked crates and battery boxes.

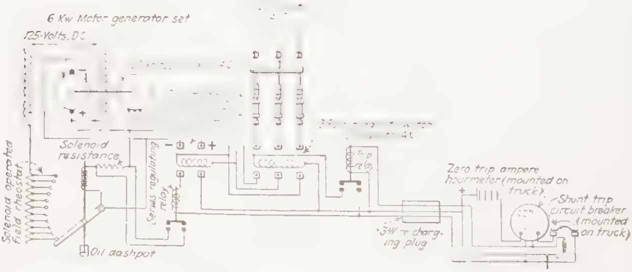
A battery box should not be washed out except when it is especially dirty or acid-soaked, in which case it is advisable to neutralize the acid with a soda solution and then wash out with a flushing hose. It is impossible to wash acid out completely with plain water, particularly when the acid has penetrated the woodwork.

When neutralized by a soda solution as described above, all traces of acid are removed and the box will quickly dry after washing. Care should be taken when flushing to prevent cells from being over-flushed.

Automatic Charging Station for Storage Battery Trucks

Here are the details of an automatic battery charging station designed to meet the needs of a small manufacturer using one electric truck. It was designed to take power from a 220-volt, three-phase alternating current circuit and to perform the following functions: First, it must start automatically when the truck driver connects the battery to the charging panel; second, it must maintain a constant current rate throughout the period of the charge, as the battery was of the nickel-iron, alkaline type; third, it must disconnect the battery in case of power failure and continue charging upon return of same; fourth, it must disconnect the battery at the completion of the charge and shut down the motor-generator set.

A 6-kw. motor-generator set was used. The normal charging rate of 38 amp. was obtained by the use of a series regulating relay and a solenoid operated field rheostat, as shown in the accompanying illustration. The series regulating relay is wound to drop its core at a current of less than 38 amp. The resistance placed in the solenoid circuit is proportioned to allow just enough current to flow to hold the core stationary. Whenever the current rate drops below normal, the series regulating relay drops its core, lowering the resistance and causes the solenoid core to rise at any predetermined speed (obtained by adjusting the oil dashpot), cutting out some of the field resistance and raising the generator voltage and charging current. When the current rate reaches the normal value, 38 amp., the relay operates, cutting in the resistance and causing the solenoid to remain stationary until further regulation of the charging is required. In operation the driver connects the battery to the charging panel by inserting the charging plug into the receptacle on the truck and pushing in the shunt trip circuit breaker.



This shows the connections for an automatic storage battery charging station.

This energizes the three-pole, 220-volt a.c. magnet switch which connects the alternating-current motor to the line, and also energizes the two-pole, 100 125-volt d.c. magnet switch which connects the battery to the shunt generator. The additional torque produced by the motorized generator reduces the a.c. starting current to a value slightly above full load rating.

Again, the value of the generator field resistance is so proportioned that when the normal speed is obtained, the voltage, with all the field resistance cut in, will equal that of the battery. After the motor generator set has reached normal speed, the series regulating relay operates as outlined above, maintaining a constant current rate of 38 amp. When the ampere-hour meter indicates full charge, the zero contacts close, tripping the shunt trip circuit breaker and the trip relay, which disconnects the battery from the panel and shuts down the motor-generator set.

A station of this kind, if carefully built, will give faithful and continuous service for a long period of time. The only attention needed is an occasional inspection of contacts and working parts and oiling the motor generator set. The slightly higher first cost of construction will be over-balanced by the better operating efficiency of the battery and the elimination of an attendant while charging.

D. F. O'DONNELL.

St. Louis, Mo.

DRYING OUT COILS

Drying Out Water-Soaked Generator Coils

Flooding of a 75-kw. belt-driven generator one night made it necessary to pump out the water in the engine room the following morning and also to make arrangements for putting the generator in working condition again.

After the water was pumped out, the generator was cleaned first by removing in a superficial way, the sediment, and then gasoline was employed.

Due to the existing circumstances it was decided to dry out the generator armature coils by driving the generator at about one-third speed while a No. 8 solid copper wire short-circuited the armature terminals.

To indicate the temperature of the coils a thermometer was taped between two of the main coils at the top of the machine, waste being packed tightly against the thermometer bulb in order to insulate it from the room temperature. The two coils selected were the ones which seemed to be operating at the highest temperature.

Shifting the field rheostat did not have much effect on the temperature of the coils, and the exciter rheostat was inoperative because of an open circuit in its resistance; therefore, increasing or decreasing the temperature of the coils was accomplished by occasionally altering the engine speed. Although an ammeter is ordinarily used to determine the amount of current flowing, none was available in this case.

Readings were taken at 15-min. intervals so as to determine whether the temperature of the coils was going up or down. During the day the temperature was maintained at 80 deg. and at night at 60 deg. C. At the end of a 26-hr. drying period, all but one of the coils had dried out and seemed to be in good condition. Usually, however, about a week is required for this drying out when no external heat is applied.

As the machine was basket wound, one coil would affect the operation of the machine a great deal. However, it was finally decided to finish the drying out process by operating the machine under normal conditions and so the terminal voltage was increased gradually to the operating voltage of 140. After a while the coil, which was suspected of being defective, began to

heat. Therefore, it was necessary to cut this coil out of the circuit.

As the cost of drying this coil would nearly balance the cost of replacing it, and it might be defective and require replacing in the end anyway, it was decided to replace it. After the job was finished, the coils were sprayed with an air drying varnish. The only spray gun available was an insecticide spray. The piston was removed and a ¼-in. pipe nipple screwed in the wooden plug in the end. An air hose was attached to this.

Birmingham, Ala. GRADY H. EMERSON.

Drying Out Shunt Field Coils

A short time ago several 250-volt d.c., shunt-wound motors, ranging in size from 10 to 25 hp., were flooded. This occurrence, of course, necessitated the drying out of the motors and so the following method was employed:

A current was applied to the shunt coils at a lower voltage than under which they would normally operate. As moisture will cause short circuits between the turns themselves at the normal motor voltage, it was thought advisable to start the drying out current at a low voltage, which could not burn the insulation even if there was practically a dead short between the turns. So 25 volts was considered a safe pressure at which to start the drying process. As the voltage was gradually increased, the temperature of the coils was watched so that their maximum temperature limit would not be exceeded.

This temperature was carefully determined by holding the bulb of a thermometer, under a piece of waste, tightly against one of the coils. To remove all the moisture in the coils in a reasonable length of time (in all probability less than 48 hr. will always suffice) a 75-deg. C. rise above the surrounding air was considered as high as it would be necessary to go.

Alternating current, when obtainable, is more effective than direct current, for the eddy currents set up in the pole pieces cause heating of the iron and bring the heat more directly in contact with the inside turns. In this case where so many motors are involved, it was most convenient to have one generator set aside for the purpose of supplying the drying out current, and the voltage regulated by varying the field current of this generator. Another plan that could have been employed, had a generator not been available, would be to drive a 50-hp., shunt-wound motor as a generator.

As the resistance of shunt field coils is quite high, they draw very little power; so the generator was used to dry out several motors at the same time. During the drying-out process the motors were covered with tarpaulin.

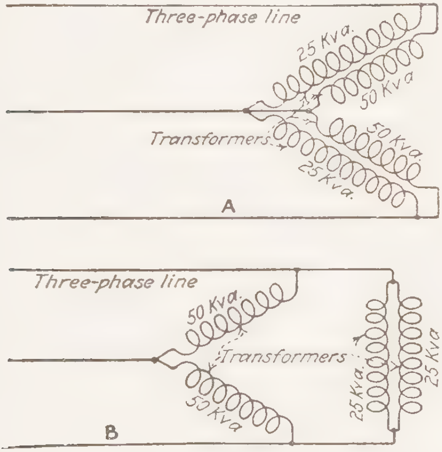
ARTHUR F. HANLY.

New York, N. Y.

Power Output Increased by Reconnecting Transformers

Relieving overloaded distribution transformers of their excessive load simply by changing from open delta to closed delta connection is a method that was recently applied by the writer. It was noticed that two 50-kva. transformers connected open delta to supply a power feeder were usually hot and in danger of burning out. It was evident that the transformers were overloaded excessively.

On further inspection of the system it was found that two 25-kva. transformers, also connected open delta, which had been added previously to the same feeder, were installed further down the line. These transformers were likewise found hot. The transformers were



Changing from open to closed delta.

Because with the overload conditions on the line the transformers on the open delta connection *A*, overheated excessively. Computation showed that because of the connection they were rated for a 130-kva. load. Reconnecting to closed delta *B* brought the rating up to 150 kva. and so relieved the condition until new transformers could be obtained.

installed in such a manner that one 25-kva. and one 50-kva. transformer constituted a set in parallel across one phase and another 25 kva. and one 50-kva. constituted a second pair across another phase. Diagrammatically the connections were as shown in *A*.

New transformers were on order but, because of the danger of a burnout occurring before their arrival, something had to be done with the present equipment, if possible. It was evident that the combined capacity

of the 50-kva. transformers connected in open delta was not 100 kva., but only 86.7 kva. Likewise, the two 25-kva. transformers had a combined capacity in open delta of only 43.35 kva. instead of 50 kva. The aggregate capacity was only 130 kva. instead of 150 kva.

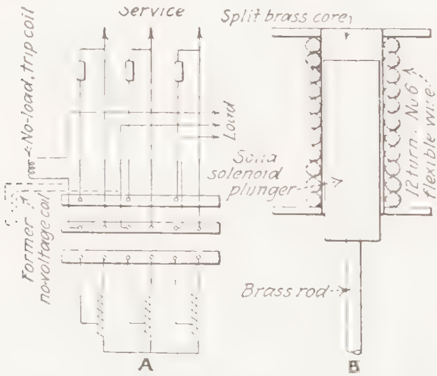
The 25-kva. transformers were disconnected from the feeder and connected in multiple with each other across the open phase as shown in *B*. This combination gave a closed delta connection and the full capacity of 150 kva. was obtained which represented an increase in capacity of more than 15 per cent. The load on the transformers was still in excess of 150 kva. but there was an appreciable reduction in temperature and the overload was carried satisfactorily.

Superintendent,
Municipal Water & Light Department,
Woodward, Okla.

HARRY J. ACHEE.

Stopping Motor When Pump Loses Suction

On several occasions I have been called on to determine why certain centrifugal pumps ran dry. Usually I have found that one or more of the pump runners had been burned out. When these jobs were checked



The plunger in the solenoid drops and trips the control switch when the load on the motor falls off.

for the cause of the trouble, it was generally found that some foreign substance had lodged in the suction pipe of the pump. After the obstruction had been removed and the pump repaired, the unit would operate normally until the next time the pump lost its suction. To prevent the continual damage to the pumps, a no-load device was eventually worked out.

For the sake of illustration I shall refer to two pump units that I have in mind. They are driven by 30-hp. and $7\frac{1}{2}$-hp. three-phase induction motors, respectively.

On the pump unit driven by the 30-hp. motor the no-voltage release coil, connected as shown in the accompanying illustration at *A*, was removed from the split brass core of the solenoid and a coil of 12 turns of No. 6 flexible rubber-covered wire was substituted. This wire was wound on the core as shown at *B* and replaced in the receptacle on the starting box.

This new coil was connected in series with the load, as indicated at *A*, instead of being connected in parallel with the motor leads, as was the no-voltage coil. When the motor is loaded, a magnetic flux of sufficient strength is produced to hold the solenoid plunger in the running position. If for any reason the motor's torque is decreased, the magnetic flux in the coil is reduced, the plunger drops out, and the switch in the starting box is tripped to the off position.

The coil used in conjunction with the 7½-hp. motor has 33 turns of No. 8 flexible rubber-covered wire. It was found that the solenoids in both of these installations gave some trouble; so the laminated iron plungers were replaced with soft iron plungers 1 in. in diameter and 4 in. long, with good results. This type of coil is very simple and exceptionally easy to install, and proved its worth the first time it operated under actual running conditions.

PHIL D. COMER.

Norco, Calif.

Changing Overload Protection to Meet Service Demands

At one of our mines we have a 400-kw. and a 200-kw., 2,300-volt, steam-driven generator. As our day load requires the use of both of these units, the circuit breakers have to be set for the combined output of the generators. Our night load calls only for the 200-kw. unit and naturally our feeder circuit-breaker setting would be too high to give any protection to the small generator. If a trolley wire became grounded, or a heavy overload came in on the line, it would almost stop the generator, perhaps causing a fire by burning out bonds or causing damage to motors from low voltage.

In order to eliminate this danger we devised a way of installing an extra relay on each feeder, using the same current transformers, by setting one relay at 80 amp. and the other at 260 amp. These relays are thrown in or out of the circuit by a reconstructed G. E. contactor and are energized from the exciter current of the 500-kw. set.

When the turbine bus switch is closed the circuit for the contactor is automatically closed, which, in turn, connects the 260-amp. relay and the plant is ready for the day's work. When the turbine switch is opened, the contactor falls out and connects the 80-amp. relay for the 200-kw. set.

H. BANHOLZER.

Electrical and Mechanical Engineer,
Knox Consolidated Coal Co.,
Bicknell, Ind.

Supporting Graphic Meters to Overcome Vibration

In a plant where it was necessary to run an extended test that required the use of graphic meters, it was found that the first records were of little value, due to the vibration transmitted to the pens of the meters. In order to overcome the effects of vibration, it was decided to suspend the meters on springs.

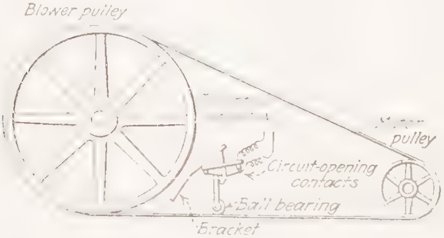
For this purpose a test bench with a top large enough to accommodate the remainder of the testing equipment, was set up. A strip of wood was nailed between the legs of the bench and a platform of the proper size for the graphic meters was suspended from the strip by means of two pieces of window chain, to each end of which spiral springs of suitable strength were fastened.

There was no further trouble from vibration and when the test was concluded the chains and springs were salvaged for future use in tests of this nature.

New Westminster, B. C., Can. W. L. STEVENS.

Protecting Heater Units When Blower Belt Breaks

The office building of the company with which I am associated is heated by a system of Glo-bar heating elements. A group of these elements is installed at each vent hole, and air for distributing this heat comes from a large belt-driven blower in the basement. In



When the belt tension is released the control circuit of the motor and heating elements is opened.

order to safeguard this installation from trouble that would be likely to occur at any time I made the protective device described below.

The purpose of this device is to cut out the magnetic switches connected to the circuit supplying the heating elements in case the blower stops due to the belt coming off or breaking. The motor driving the blower is operated from a General Electric 7,006 push-button magnetic switch. Energy for operating the coils on the magnetic switches controlling the heaters

is also taken from the push-button switch, so that the heat is turned on whenever the motor is running.

A stop-button unit was taken from a spare General Electric compensator, and in place of the ¼-in. pin extending from it, a piece of 16-gauge iron about ½ in. wide and 12 in. long, bent in a U-shape with about ¾ in. between the sides, was installed.

A ball bearing about 1½ in. in diameter and ½ in. wide was then placed on a small shaft driven through the end of this extending arm, as shown in the illustration. A coil spring was made to take the place of the original piece of flat spring steel in the push-button unit. The original spring was too weak to withstand the constant pressure and motion that were necessary in the operation of the new unit. A small grease cup was installed on the ball bearing shaft to keep the bearing lubricated.

The whole unit was then installed in such manner that the ball bearing rides the blower belt on the inside. A bracket for holding the belt contact device was installed on the bottom of a staircase running close to the blower pulley. This device makes contact on the bottom, or the pull side, of the belt so that a comparatively uniform tension is maintained against the contact of the stop-button unit.

The control circuit of the switch supplying the motor was cut open and connected to two wires run in flexible conduit to the new belt-riding contactor. If the belt should break or slide off the pulleys the tension against the ball bearing, which holds the control circuit closed, would be released, thus stopping the motor and opening the heater circuit switches.

D. W. Haire.

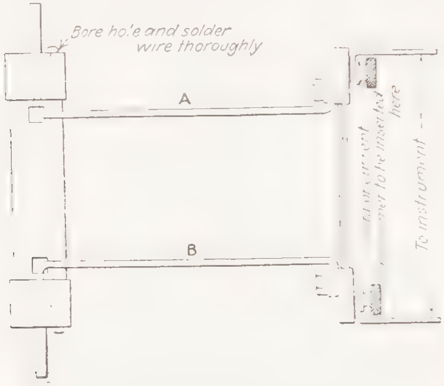
Pinedale, Calif.

Cutting Meter Into Circuit

Quite often it is necessary for the plant electrician to measure the amperage of a motor or of a circuit. In such cases there is seldom a handy place for cutting in a measuring instrument on the line. So I have adopted an arrangement that will allow either a direct-current or an alternating-current ammeter to be readily connected to the desired circuit. This is accomplished by cutting in a shunt for direct current, or a current transformer for alternating current at the fuses protecting the circuit.

First of all, several different sizes of fuses can be salvaged from the fuse junkpile. My last collection of such fuses included four sizes, 30-, 60-, 90- and 150-amp., for operation on a 600-volt circuit. Holes should be cut in the fiber at each end near the ferrule, as shown in the illustration, to accommodate wire of ample size to carry the current. After the wires have been soldered into the holes in the ferrules, the excess copper and solder projecting through the ferrule should be filed off.

When it is desired to measure the current in any circuit or in any particular motor, only a few moments are needed to remove the fuses protecting the circuit, insert the blown fuses with wires attached, connect the ammeter, and then close the switch.



The test circuit leads are connected to the ferrules of blown fuses which are temporarily inserted in place of the fuses protecting the equipment.

For a d.c. line a shunt is attached to wires *A* and *B*, as shown in the illustration, and for an a.c. line a current transformer is attached to these test wires. If it is desired to use a graphic wattmeter, two such blown fuses are employed.

When the test fuse connectors are not in use, they take up but little space in the shop; on the job they are real time-savers.

CHAS. A. PETERSON.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Voltage Records Used to Select Proper Lamps

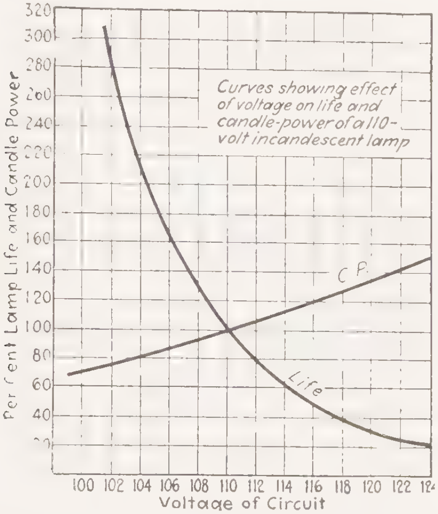
Prior to the installation of a graphic voltmeter, a plant in the industrial district of a large city was buying 110-volt lamps and getting about 50 per cent of the rated life. The lighting and power were supplied from the same feeder, but with separate transformers. However, during the day, when all the plants of the district were operating, the lighting voltage averaged 115 volts, but during the night it ran as high as 130 volts. As a result, they are now buying 115-volt lamps for all circuits except those used at night, on which 125-volt lamps are used.

All this tends to substantiate the importance of the present-day incandescent lighting problem, of which cost of electricity and cost of lamps are the two most important elements. An incandescent lamp consumes

its rated wattage, gives its rated candlepower and lasts its rated life only when supplied with its rated voltage. If the voltage supplied to the lamp is less than the rated lamp voltage, the candlepower and the wattage consumption are decreased and the lamp life is lengthened.

If the voltage supplied is greater than the rated lamp voltage, the candlepower and the wattage consumption are increased and the lamp life is shortened.

The balance between lamp life, light obtained and energy consumed, all of which vary with the voltage, is a rather delicate one to maintain, since the candlepower varies directly as the 3.5 power, and the life of the lamp inversely as the 13.5 power of the voltage. It is apparent, therefore, that a voltage too low for the



Curves showing effect of voltage on life and candlepower of 110-volt incandescent lamp.

In order to determine lamp life and candlepower of 110-volt lamps at other than rated voltage, trace upward from voltage of circuit, intersecting curves. From these points of intersection, trace left to column, per cent lamp life and candlepower. For instance, 100 per cent lamp life of 110-volt lamps is shown at intersection of curves.

lamp greatly reduces the amount of light obtained, and a voltage too high greatly shortens the life and increases the cost of the lamps.

In order to show what this means, the Esterline-Angus Co., Indianapolis, Ind., has computed, from data supplied by the National Electric Lamp Association, the curves of life and candlepower of 110-volt lamps when burned on circuit voltages of from 100 to 125 volts.

These curves show the necessity of knowing accurately the voltage in buying lamps, and of maintaining voltages for which lamps have been supplied. For example, a 110-volt lamp supplied at 112 volts suffers a reduction in life of 21 per cent and of 38 per cent if supplied at 114 volts.

Since the light given and the watts consumed increase with the voltage, while the lamp life is decreased, there is, depending upon the price of lamps and the price of a kilowatt-hour of energy, a relation between circuit voltage and the lamp voltage rating, which will give the minimum cost of light.

Therefore, in order to buy and use incandescent lamps intelligently and economically, the voltage at which they are to be used must be accurately known. Every consumer of consequence will find it profitable to use a reliable recording voltmeter, and buy lamps of the proper voltage rating, as determined from the records of the instrument.

Control to Stop Motor When Conveyor Clogs

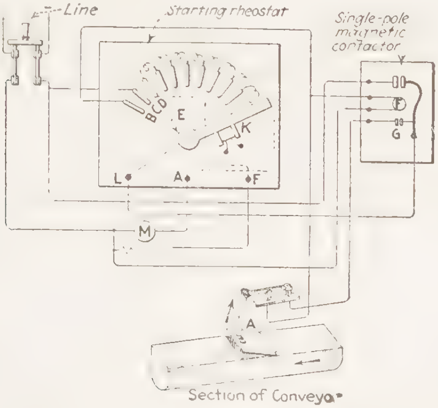
The control system for conveyor motors shown in the illustration is in service in an Iowa plaster mill and has eliminated considerable trouble since it was installed. An explanation of the conditions under which this device operates will help the reader to understand its purpose.

A screw conveyor about 120 ft. long is used to move plaster from one building to another, the conveyor screw being 12 in. in diameter. Occasionally the bin at the discharge end of the conveyor would become filled up and cause the conveyor to stall. If the attendant was busy somewhere else at the time, either a belt or the paper pulley on the motor would be destroyed. It was finally decided to install some device to shut down the motor when the conveyor became clogged up. For this purpose, a 16-in. section of the conveyor was arranged as a hinged door opening upward. This door is shown at *A* in the illustration. It was connected to a single-pole, inclosed switch which opens when the material being handled clogs and presses against the hinged door hard enough to lift it up.

The original arrangement of the starting rheostat was changed somewhat, as shown at *B* and *C*. The resistance coil formerly connected between contacts *C* and *D*, and the spring *E* for returning the starting handle to the "off" position were removed. A single-pole magnetic contactor and the necessary wiring completed the job at a very small cost.

Assuming that the motor is idle and ready to be started, it is first necessary to bring the rheostat handle to the "off" position, thus bridging contacts *B* and *C*. This will close the circuit through the coil *F* of the contactor. The handle of the rheostat can now be moved forward to start the motor, as the contact maintaining stud *G* will keep the contactor in a closed posi-

tion, if switch *A* is closed, although contacts *B* and *C* are no longer bridged. If the conveyor clogs, the hinged door is pushed up, opening switch *A*, and thus breaking the circuit to contactor coil *F*. The contactor in turn opens the motor circuit and stops the conveyor.



The pressure of the material in the conveyor raises the hinged door, opening switch A, which, in turn, causes the contactor to open the motor circuit.

In order to start again after clearing up the conveyor trouble and closing the switch *A*, the rheostat handle must again be brought to the "off" position at *B* and *C* in order to start the motor. The low-voltage release coil, *K*, is not used, but voltage failure will cause the contactor to open, which, in turn, stops the motor.

The idea involved in this control arrangement can no doubt be modified to suit other industrial applications.

CHAS. A. PETERSON.

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Fairbanks Exploration Co.,
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Use of Potentiometer to Supply Power for Signal Systems

For economical reasons, lighting circuits are now frequently used to supply electric current to low-voltage systems in place of the much used wet or dry cell batteries. The increasing use of low-voltage equipment, such as indicators, bell systems, telephones and the like has induced a large organization to utilize potentiometers with 110-volt, d.c. circuits, whenever practical, to supply the desired low voltage.

The simple potentiometer used consists of a correctly designed resistance coil placed across the mains with

taps to give the desired voltage. The load characteristic of a potentiometer is similar to the external characteristic of a self-excited, shunt-wound generator; that is, an overload causes a rapid drop in voltage, which may fall to zero. For any particular load, the voltage may be increased by decreasing the total resistance of the potentiometer, or by taking off the load from a higher tap. If a higher tap is used, however, the voltage delivered at no-load is increased. Hence, for economical operation, the balance between the total current consumed and the no-load voltage is the problem of design.

This latter statement may be better understood by referring to Table A. This table gives the calculated

Voltage and Current Characteristics of Potentiometer Under Different Load Conditions

Resistance of Load *DE* in Ohms	Effective Resistance of *VC* and *DE* in Parallel	Total Effective Resistance Between *A* and *C*	Ampere Input to Potentiometer	Volts Applied to Load *DE*	Load, *DE*, in Amperes	Load, *DE*, W.
A—Total resistance of potentiometer coil AC equals 100 ohms						
40	13.30	93.3	1.07	14.4	[illegible]	[illegible]
20	10.00	[illegible]	1.11	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	7.7	[illegible]	[illegible]
5	4.00	84.0	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	1.21	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	1.24	[illegible]	[illegible]	[illegible]
B—Total resistance of potentiometer coil AC equals 10 ohms						
40.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	[illegible]	[illegible]	[illegible]	[illegible]	1.73	[illegible]
5.0	1.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.20	[illegible]	[illegible]	[illegible]	[illegible]	57.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	46.1

performance of a potentiometer having a total resistance of 100 ohms and a 20 per cent tap to supply the low-voltage circuit. The potentiometer is connected across a 100-volt supply. The table gives the performance of the potentiometer under different loads.

Referring to Fig. 1, the effective resistance of *BC* and load in parallel = [20*DE* ÷ (*DE* + 20)]. In this case the resistance *BC* is represented by 20 ohms. The total resistance in ohms across the service line *AC* is [80 + (effective resistance of *BC* and *DE* in parallel)]. In this case 80 ohms represents the resistance between *A* and *B*. The total current in amperes supplied by the service line is 100 ÷ [80 + (effective resistance of *BC* and *DE* in parallel)]. Voltage between *DE* or *BC* = (current through *AB*) × (effective resistance of *DE* and *BC* in parallel). The current through the load = (voltage of *DE*) ÷ (resistance of load).

Table B shows the increase in voltage and current obtained through the same load values when a 20 per cent tap is taken from a 10-ohm coil instead of a 100-ohm coil, as was the case in section A of the table.

The maximum output in watts is obtained from the potentiometer when the internal resistance BC and the load resistance DE are equal. This fact may be often used to advantage as the basis of design.

For example, if current is to be supplied to a two-circuit, electro-mechanical gong fire signal system, supervised by the full operating current of 125 mil.-amp. per circuit, a constant load of 0.25 amp. at 20 volts is required. By Ohm's law the resistance of the external circuit is $R = E \div I$, or $R = 20 \div 0.25 = 80$ ohms. Making use of the maximum output, as explained in the preceding paragraph, fixes the resistance of the DE-BC section.

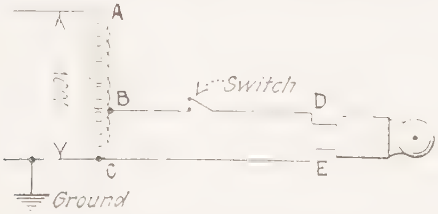


Fig. 1—Typical potentiometer layout for low-voltage signal systems with only a small variation in the current demands.

The direct-current lighting circuit leads are connected to the potentiometer at A and C, the ground connection being connected to lead C. The location of top B together with the resistance of coil AC is selected in accordance with the lighting voltage and the current requirements of load DE.

The first column of the table gives the resistance of the load. In Fig. 1 let DE represent a load of which the resistance can be varied at will, and AC a potentiometer having 100 ohms total resistance with a 20 per cent tap at point B. Now, when the resistance of DE is 40 ohms, we find that the effective resistance of BC and DE in parallel, that is, the effective resistance of 20 ohms in parallel with 40 ohms, is equal to $(R_{BC} \times R_{DE}) \div (R_{BC} + R_{DE}) = (20 \times 40) \div (20 + 40) = 800 \div 60 = 13.3$ ohms, as given in the second column, first line. Then the total resistance between points A and C equals $13.3 + 80 = 93.3$ ohms, as given in the third column. The total current supplied to the potentiometer will be $100 \div 93.3 = 1.07$ amp., as given in the fourth column. To find the voltage supplied to the load, we first determine the voltage drop over AB, which is equal to $1.07 \times 80 = 85.6$ volts. Subtracting this from the line voltage we get $100 - 85.6 = 14.4$ volts supplied to load DE, as given in the fifth column, first line of table. Then the current input to the load will be the voltage delivered by the potentiometer divided by the load resistance which equals $14.4 \div 40 = 0.36$ amp. as given in the sixth column, first line. Comparing the first and fifth columns, we find that a change

in the resistance of the load will cause a large change in voltage delivered to the load.

As the voltage across DE is 20 volts, section AB must then absorb the difference between the load and supply voltages, in this case 100 — 20, or 80 volts. But since the resistances of the BC and DE sections are equal, the current in each leg is 0.25 amp. and the current through the AB section is 0.5 amp. which fixes the resistance of AB as $R = E \div I$, or $80 \div 0.5 = 160$ ohms, which takes care of the 80 volts between A and B. It is also desirable to check the no-load voltage obtained when the external load is removed. In this case the resistance of the AB and BC sections are 160 and 80, respectively, making a combined resistance of 240 ohms between the 100-volt service lines. Since the BC section is a third of the full resistance between the service lines, the no-load voltage is 33.3 volts.

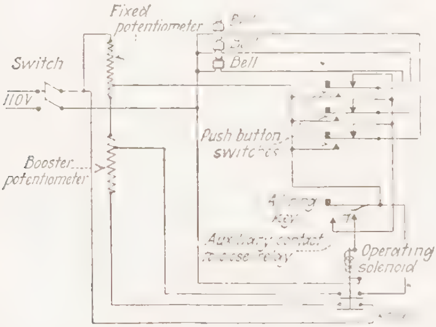


Fig. 2—Using a booster potentiometer to supply intermittent demands for more current.

The fixed or permanently connected potentiometer handles only light loads, such as ringing small bells and the like. When heavier demands for current must be met, the booster potentiometer is cut into the circuit by means of a relay.

The great advantage of potentiometers is most apparent when the external load is intermittent in character, in which case a booster potentiometer may be brought into service by means of a relay and in this way take care of any heavy load during the time for which the load is to be supplied. Booster relays might be used for fire signal systems where the full operating current is not required for supervision, for all-ring, classroom-bell operation in school buildings and for many other uses. Fig. 2 indicates a typical layout for such a system.

Commercial resistances are rated in watts, in which case the current supplied is dissipated as heat or $I^2 R$ losses. Generally, commercial resistances are rated 200 watts continuous duty and 500 watts for 20 seconds. The simplest form of resistance for potentiometer use

is a bare wire wound on an insulating tube. Adjustment of voltage can be conveniently made by means of a movable slider. In another form of potentiometer permanent taps are brought out from the coil, and the joints, together with all of the coil, are then covered with a vitreous enamel and fired.

Potentiometers may be mounted in the open on a slate switchboard or enclosed in a metal cabinet. If enclosed, asbestos wiring had best be used because a non-ventilated cabinet will often radiate more heat than a ventilated one for the reason that the whole cabinet is raised an equal amount above the ambient temperature and the whole surface is available for heat dissipation and thus localized hot spots are more often avoided. However, each case must be treated individually, and as most potentiometers for this class of work need not radiate more than 50 watts continuously, the usual precautions accorded to electric lamps of similar watt consumption are all that is necessary.

New York, N. Y. LEO S. LOOMIE.

Effects of Overvoltage on Contactor Coils Reduced by Using Reactors

Varying line voltage is the source of considerable trouble with the operating coils of contactor.

These devices are often abused by imposing on them voltages above their rating, with the result that the insulation becomes baked, making a breakdown inevitable. When it is necessary to use an outside source of current, whose voltage is higher than the coils are designed for, or when the voltage of the plant supply is too high, it is well to provide some means of bringing this voltage down to meet the requirements of the contactor coils.

A 5 per cent variation from the rated voltage is all that coils should be called upon to handle, and if the voltage of the supply circuit is more than 5 per cent too high or too low, trouble will likely be encountered sooner or later.

I recall an installation which was put in a few years ago, where the coils were designed to operate on 440 volts, but the supply circuit was badly overtaxed with varying loads, causing serious voltage fluctuations at the coils that resulted in burned-out coils. This fluctuation, which ranged from 480 to 500 volts, amounted to a minimum over-voltage of 10 per cent and occasionally rose to 13 per cent or more. The coils in question were contactor coils on a Westinghouse automatic synchronous motor panel. Outside service of decidedly poor character was used and the fluctuations were due to an overloaded system feeder carrying 60-cycle a.c. current.

To protect the coils a reactor was chosen in preference to a resistor, partly because we had no resistor on hand, whereas the parts for a reactor were available.

The number of turns required for the reactor was first based on a guess. After the reactor was connected up the voltage of the supply circuit and at the coil terminals of the coils was checked by a voltmeter. The difference in the readings was divided by the number of turns in the reactor which gave us the correct value per turn, after which we added enough turns to obtain the result desired.

The contactors operated by these coils weigh about 350 lb. per panel. There were four panels per board, or a total of six panels, including the operating panels.

As we were not designers of reactors, we measured the area of the iron in the contactor core and put the same amount in our reactor.

The iron core was obtained from a discarded transformer and probably could not be considered the best, but it served our purpose. The number of turns to be used was another item that a designer could state in a few minutes, but in our case we experimented with wire the same size as that used in the contactor coil, until we were satisfied. The voltage was cut to the proper value, and thereafter no more coils were destroyed.

As ours was but a temporary arrangement, the iron was stacked in the usual manner, but in the form of a square, in order to use the iron without cutting. The corners were held together by C clamps and the unit was supported by glass-insulated spools.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

E. J. MORRISSEY.

Using Flashlight for Testing Fuses

The present-day, fused safety switch has a separate compartment for the fuses, the door of which cannot be opened until the safety switch is open. This is done for safety reasons, so as to prevent anyone from changing or inspecting the fuses while they are alive. However, it prevents testing the fuses in the usual manner by shunting a test lamp across a pair of fuses while they are "hot."

To test the fuses that are used in a safety switch of this kind, it is necessary to remove them from the fuse blocks and test them with a magneto, or by connecting them through a test lamp with a source of power. At our plant we have devised a method of testing these fuses which is much more convenient and fully as reliable as the two methods just mentioned.

All of our motor inspectors carry small flashlights that have fiber cases. We have soldered a strip to the top connection of the switch on the side of the flashlight case; the other end of the strip is soldered to the metal band on the fiber case that screws into the cap, which holds the lens and the reflector. With this arrangement we are able to test a fuse by shorting it across the metal bands or ferrules at the top and bottom of the flashlight.

On some types of flashlights having fiber cases, the top and bottom caps or ferrules form part of the electric circuit that lights the bulbs. In such cases, if the flashlight should be laid down on a metal sheet, the light will burn even though the switch is off. With this type of flashlight the fuse may be shunted directly across the top and bottom ferrules and if the fuse is not burned out the flashlight will burn.

Chief Electrician,
Shevlin-Hixon Co.,
Bend, Ore.

WM. B. CONE.

Limit Switch to Prevent Overtravel of Hoist

A hoist to dump cars was recently equipped with an automatic limit switch to prevent careless operators from allowing the hoist to go beyond safe limits. This hoist is driven by a 25-hp., 440-volt, three-phase, Westinghouse slip-ring motor, which is geared 10 to 1 to the 10-in. cable drum.

A piece of cold-rolled steel threaded on a lathe was screwed in a hole, drilled in the end of the drum shaft, and tapped for a U.S. standard ¾-in. bolt, as indicated at *G*, in Fig. 1. A traveler, *C*, was made to operate on the threaded rod, *F*, when the drum revolves. This traveler moves away from the drum when it revolves

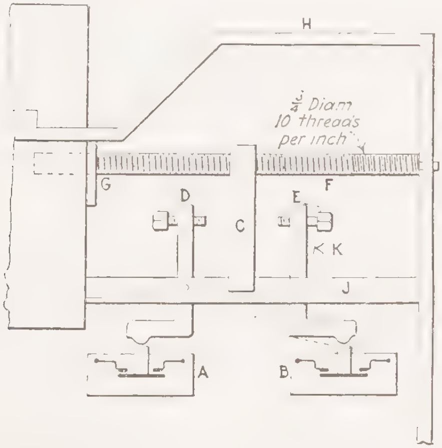


Fig. 1—This switch is used to limit the travel of a hoist by opening a contactor.

in one direction, and toward the drum when it revolves in the other direction.

The limit stops *D* and *E* cause the contactor *L*, in Fig. 2, to trip whenever the drum travels too far in either direction. The setscrews shown at *D* and *E* are for the purpose of closely adjusting the limit of travel

of the drum. General Electric type CR2940 BS211A push buttons are used at A and B, Fig. 1. During the normal operation of the hoist, these buttons are closed. A piece of light angle iron, J, was used to keep the traveler in a perpendicular position by means of a slot cut in the lower end of C sliding over one side of the angle iron. The dotted line K indicates the position of E when the button B causes the contactor L to trip.

In order to start the hoist after the automatic limit switch has tripped, it is first necessary to put the controller handle in the off position, to close the control circuit through the reset contact. This closes the circuit up to switch M. By closing the top contact of switch M, the two-pole, 60-amp., 440-volt Cutler-Hammer contactor L, Fig. 2, is made to close, if switches A and B are closed. But if switch A_1 is open, switch A must be closed and the motor started by moving the controller handle. When the traveler C, in Fig. 1. has moved far enough to allow switch A to close, then

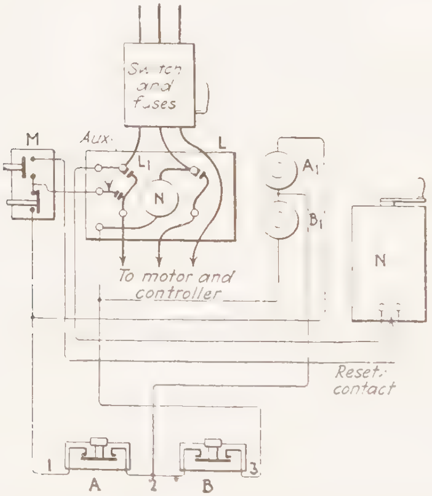


Fig. 2—This diagram shows how the limit switch, shown in Fig. 1, was connected to the motor control circuit.

switch A, and the top contact of switch M can be released. Likewise B_1 allows the operator to close the contactor after it has been opened by overtravel in the opposite direction, which results in B opening the control circuit.

Whenever switches A and B have opened, the starting procedure just described must be followed out. Of course, when switches A and B are closed and contactor L is open, it will only be necessary to put the control handle in the off position and close the upper contact

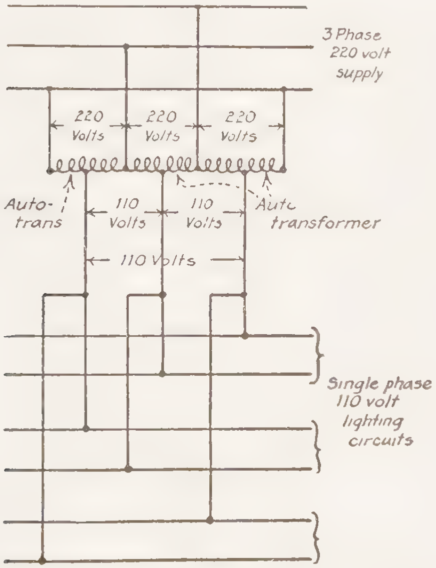
of switch M; then the contactor will remain in the closed position without continuing to keep the upper contact of switch M closed.

CHAS. A. PETERSON.

Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Improved Method of Connecting Auto-Transformers for Lighting Circuits

In a great many industrial plants the power supply is three phase, 220 or 440 volts, and the lighting supply is obtained from these power circuits by means of transformers connected thereto. It is quite common practice,



Use of this connection of auto-transformers on lighting circuits prevents danger of overvoltage due to grounds.

As may be seen, the feature of the connection lies in the fact that the lighting circuits are connected between middle points of adjacent auto-transformers which, due to the fact that the voltages in each transformer are 120-deg. out of phase, gives a voltage of only 110 volts.

to connect an auto-transformer across one phase of the three-phase supply, the auto-transformer having a mid-tap, so that a 220/110-volt three-wire, single-phase supply is obtained. This system has several disadvantages, the more important of which are as follows: As all of the lights are connected to only one of the three phases,

the lighting load unbalances the power circuit to a certain extent. A ground on the neutral wire in a three-wire lighting circuit is likely to disturb the equality of voltages in the three-wire circuit and may place as high as 220 volts across the 110-volt lamps.

In the connection scheme shown in the accompanying diagram, three auto-transformers are connected in delta across the three-phase power supply. Now, instead of using the line wires through the auto-transformer as well as the mid-taps, only the mid-taps are used to supply the 110-volt lighting circuit. The voltage between any pair of mid-taps is equal to the vectorial sum of half the voltage in the two auto-transformers to which the mid-taps connect. In other words, the resulting voltage equals $2 \times 110 \times 0.5 = 110$ volts. This is due to the fact that the two voltages are 120 deg. out of phase, thereby resulting in a voltage of only 110 volts.

With this connection scheme, three 110-volt, single-phase lighting circuits are obtained, which are 120 deg. apart in phase relation. By balancing the lighting load equally across these three single-phase circuits a good balanced load condition will be obtained.

An advantage of this connection scheme lies in the fact that grounds will not disturb the voltage on the different circuits and it is impossible to obtain overvoltage, thereby burning out lamps. However, it should be remembered that with this connection of auto-transformers it is quite easy to overload them, for in the more usual connection with a balanced load between the two outside wires of the three-wire circuit, the transformer is required to carry very little load, as practically no current flows through the neutral wire. With the connection scheme just described the total lighting load passes through the auto-transformers, and due consideration should be given this fact when deciding upon the size of auto-transformers. However, I think that the elimination of overvoltage due to grounds will overbalance this disadvantage.

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Knoxville Iron Co.
Knoxville, Tenn.

Saving Made by Eliminating Lightly Loaded Transformer Bank

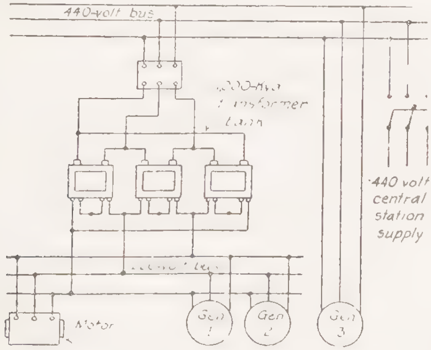
For industrial plants which generate their own power during the day, and purchase auxiliary power for night lighting or occasional motor use, it is advisable from an economic standpoint to have the motors that are used at night of the same voltage as that of the central station supply, as will be illustrated in the following example.

The power supply of a certain large industrial plant was as shown in the accompanying diagram. Generators *1* and *2* were both rated 220 volts, three-phase,

while generator *3* was a 440-volt, three-phase machine. The connected plant load consisted principally of 220- and 440-volt motors. This arrangement was the result of combining old and new equipment and was designed with the idea of ultimately changing entirely to 440-volt service.

It was found necessary on certain work to operate a 40-hp., 220-volt motor for 14 hr. each night over a period of several years. This necessitated operating one of the 220-volt generators at night or using purchased power which was already in use in the plant. Naturally, it was much cheaper to use the purchased power; however, this power was supplied at 440 volts, and since the motor was rated at 220 volts, using purchased power necessitated switching in the 1,000-kva. transformer bank normally used for changing the voltage from 440 to 220.

Through the use of an indicating wattmeter on the central station power feeder, it was found that at very light loads the transformer bank had an excitation load of 16 kw. This represented a waste of power that could



The 40-hp., 220-volt motor was reconnected for 440 volts and fed from the 440-volt bus, thereby eliminating the transformer bank.

be avoided by the use of a 440-volt motor, as it would then not be necessary to use the transformer bank at night.

Accordingly, the connection of the stator coils was changed from parallel to series, and the motor cables were tapped onto the 440-volt feeder.

The saving made possible by elimination of the use of the transformers was 16 × 14 × 0.031 (cost per kw.) × 300, or $2,082 per year. The labor and material cost for reconnecting the motor was approximately $65. A better power factor was obtained and the line losses between the motor and switchboard were also decreased somewhat.

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Interlocking Control System for Overhead Tramways

The following scheme was proposed for transporting crushed rock from a quarry to a cement mill located approximately 5½ miles distant, by using three overhead tramway systems with buckets suspended for carrying the crushed rock. The material is carried uphill out of the quarry by tramway No. 1, shown in the diagram, and then down grade to where it connects with tramway No. 2. Tramway No. 2 takes the material and conveys it to No. 3, which delivers it to the cement mill.

Buckets are suspended at equal intervals from the overhead cables of each of the three tramways, so that when a full bucket from No. 1 arrives at the dumping place, an empty bucket from No. 2 is ready to receive it. Similarly No. 2 tramway disposes of its load to No. 3. As a matter of fact, a small amount of storage space is available between the tramways, but only enough to take care of one bucket load. It was, therefore, essential that the speeds of the three tramways be kept the same, although it was not desired to use a complicated control.

To accomplish the desired results, it was proposed to drive each of the three tramways by a 100-hp., 900-r.p.m., 440-volt, three-phase, 60-cycle, slip-ring motor equipped with a solenoid brake. When the tramways are at rest something in excess of full-load torque is required to start them moving, but when all the descending buckets are full, the motors of No. 2 and No. 3 tramways are overhauled and act as induction generators, developing approximately 80 hp. and 90 hp. respectively, and pumping current back into the line.

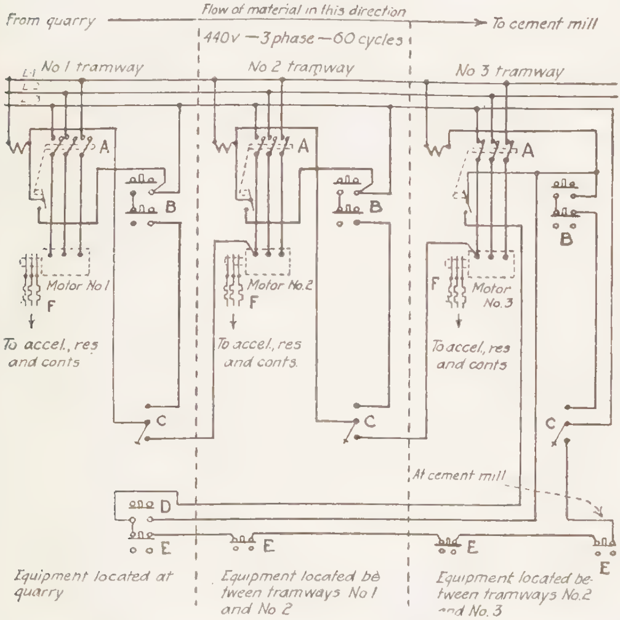
Tramway No. 1 differs from the other two in that the full buckets descending the 6 per cent grade are more than counterbalanced by the full buckets coming up the 16 per cent grade and it is necessary for the motor to supply the extra power necessary to operate this tramway. As this motor is always pulling a load, it can never run as fast as 900 r.p.m.; its speed will always be less than this value. On the other hand, the other two motors, being overhauled, will always run above 900 r.p.m.

It is a well known fact that the speed of a slip-ring induction motor can be changed within certain limits, by varying the amount of secondary resistance. It is probably not so generally known that inserting secondary resistance tends to increase the speed of the machine when it is acting as an induction generator, although it will decrease the speed when operating as an induction motor.

If all three tramways were geared to their respective motors with the same gear reduction it would never be possible to fulfill the requirement of operating them all at the same speed. No. 1 tramway would always operate slower than No. 2 and No. 3. It was necessary, therefore, to gear up the speed of No. 1 tramway

slightly above the regenerative speeds of No. 2 and No. 3 and get speed adjustment by inserting resistance in the secondary of No. 1 motor. Besides the permanent resistors for final speed adjustments, the control equipment included three standard, General Electric, type CR-7012-B1 starters and accelerating resistors with standard push button stations.

Important requirements of operation were: (1) Under usual conditions of operation all three tramways must operate at the same time when conveying material. (2)



Control apparatus used to operate overhead tramway system for transporting crushed rock from a quarry 5½ miles distant from the cement mill.

A, line contactors for motors Nos. 1, 2 and 3. *B*, "Start-Stop" push button stations for individual operation of the motor starters. *C*, selective snap switches to operate motors in sequence or individually; "down" for sequence operation and "up" for individual operation. *D*, start button used for sequence operation when selective switches *C* are in the "down" position. *E*, emergency stop buttons. *F*, permanent resistance to adjust speed.

Stopping of any tramway must always cause No. 1 tramway to stop; otherwise there would be a piling up of material at the stalled tramway. (3) In case of an emergency it must be possible to stop the entire system from any one of four locations; that is, at each motor

installation and at the cement mill. (4) If desired, any tramway must be capable of being operated independently of the others for the purpose of testing out motor and control equipment.

As indicated in the diagram, tramway No. 3 is started by the proper push button station located at the quarry. As soon as the line contactor of No. 3 motor closes, No. 2 motor starts up. Similarly, No. 1 motor starts when No. 2 motor contactor closes. Therefore, No. 1 motor will always shut down no matter which motor stops, which will prevent piling up of material between any two conveyors. In case it is desired to operate any starter without its being in sequence with the other two, this can be accomplished by pushing the proper double-throw snap switch *C* to the "up" position.

The above system of overhead conveying makes it possible to carry material over forest land, swamps, ridges, ravines, and so on. Also, since the material is mainly carried down grade, it is possible to obtain braking by the regenerative action of the motors, the economy of which is two-fold; (1) The regenerative current from the motors is used to run motors in the cement mill and quarry, thus reducing the load on the power plant. (2) Regenerative action is superior to mechanical braking as there is an entire absence of mechanical friction and consequently there are no brake shoes to replace or periodically adjust. The solenoid brakes referred to previously are used only as holding brakes when the tramways are at rest, or for deceleration in emergencies when the motors are shut down because of overload or voltage failure.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

R. F. Emerson.

Facts to Remember About Care of Renewable Fuses

A fuse is the maintenance man's best friend, when it is properly applied and cared for; otherwise it can be a source of no end of annoyance, as well as the cause of considerable delay to important machines which it is supposed to protect. Although renewable fuses are extremely simple, there are several precautions that should be observed in using them. It is surprising, but true, that some maintenance men will install a fuse improperly and expect it to give good service. It is sometimes still more surprising to visit some power plant and note the number of fuse cases, terminals and so on laying around that have been burned up or so badly damaged that they are of no further use. I cannot say just what the life of a good renewable fuse should be, as I have never had to take a fuse case out of service, in spite of the fact that I have refilled them hundreds of times and used them in some cases at 100 per cent above their rated capacity.

With this in mind, the following procedure may be of help to maintenance men who have been having trouble with fuses.

First, I always keep a duplicate set of fuses ready for use in a small rack in the power house. Under each set of fuses is marked the equipment on which these fuses are used and the rating that is best suited for its protection. When a set of fuses fails anywhere in the plant, I can replace it with the extra set in a very short time indeed.

As soon as possible, I take the blown fuses apart, polish the terminals and washers, and also the fuse links, if they are old and discolored, with a small piece of No. 00 sandpaper, and assemble the fuse carefully. I take particular care to make a good, tight fit between the link and the terminals. Right here is where a great many maintenance men make a mistake: they do not tighten the link in the terminals as well as they should, which results in a temperature rise at the terminals when the fuse is put under load. The heat is in turn passed along to the link and the result is a premature failure.

Another very important point that deserves more attention than it usually receives, is the condition of the fuse clips. I make it a point to go over all fuse clips at least once a month, remove the fuses, and carefully wipe the inside of the clips with a folded piece of No. 00 sandpaper where they make contact with the fuse terminals. After doing this I try the fuse in the clip, noting carefully whether both clips make a good, firm contact with the fuse terminals. If not, it takes only a few light taps near the base of the clip to make a tight fit. A little experience will soon enable one to do this.

Another important point to watch is whether the fuse clip is making contact with the fuse terminal on only one corner or either side of the clip. By inserting and withdrawing the fuse a time or two, one can see by looking at the fuse terminals just what parts of the clips are making contact with the fuse terminals. In a surprising number of cases, fuses make contact on just a very small part of the clip. If this condition is not corrected, the fuse cannot possibly carry its rated load, due to the fact that the area of contact is so small that it will heat up when the fuse is put into service. The result is premature failure, causing unnecessary delay and expense. Besides this, the fuse terminals and clips will probably be burned, in some cases so badly that they can not be used again. In any case, heating anneals the fuse clips and takes all of the life out of them. With the larger sizes of fuses, this heating, in addition to burning the fuse terminals and annealing the fuse clips, may also cause the fuse to crack and split open.

All of the above instructions can be carried out in much less time than it takes to explain them. If they are complied with, it will be found that fuses will give

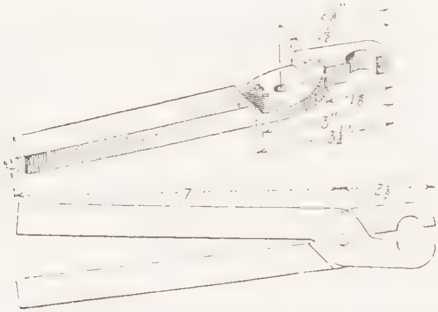
not only months but years of faithful and reliable service, eliminating the annoyance and delay to production occasioned by premature failures due to abuse and improper care.

F. D. HEWLETT.

Chief Electrician,
Ingham-Burnett Lumber Co.,
Allison, Ala.

How to Make Inexpensive and Durable Fuse Puller

Although fiber fuse pullers can be purchased, many electricians prefer to make their own. Some idea of the life of a home-made fuse puller may be judged from the fact that the one I am using was made by me over 13 years ago.



Red fiber is a good material from which to make a fuse puller.

The accompanying sketch gives the dimensions of a puller that will handle cartridge fuses up to 100-amp. rating. If larger fuses are to be handled, the dimensions of the puller must be increased.

It was made from ½-in. red fiber. This was first cut to the approximate shape with a hacksaw; then the surface was smoothed on an emery wheel and later with a file.

CHAS. A. PETERSON.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

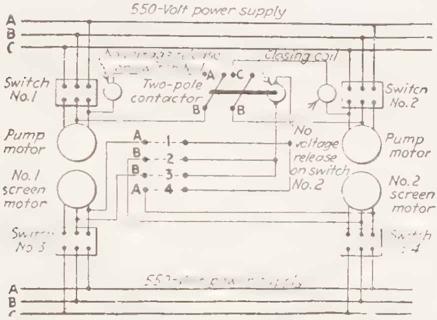
Interlocking of Screen Motor Control Prevents Damage From Overflow

Some paper mills are troubled with stock running over in screen rooms and flooding things generally. In our mill we have found a way to prevent this overflow by having the pump motors shut off automatically when the screen motors stop. The starters of the screen motors and the stock pump motors are so interconnected through the no-voltage release coils on the pump

starters, that in case either screen motor stops, both pump motors are shut down.

This interconnection was made by the use of four fuses and a 550-volt, double-pole contactor with a single closing coil. The accompanying wiring diagram shows the arrangement and connections. It might be of interest to know that the pumps are in the basement and that the screens are located in a gallery on the first floor, the operator being unable to see the screen from where the pumps are located.

With the arrangement shown in the accompanying scheme, it is impossible to start either or both of the pump motors unless the proper number of screen motors have been placed in operation. This is accomplished by interlocking the control of the pump motors with that of the screen motors. In order to operate either or both of the pump motors, it is necessary to energize



The coil of the contactor which closes the circuit to the no-voltage release coils for the pump motor control can be energized only when the screen motors are running.

the closing coil of the interlocking contactor, which closes the circuit through the no-voltage release coils on the switches controlling the pumps.

Current for energizing the contactor closing coil can be obtained only when one or both of the screen motors are running, as follows: When screen motors Nos. 1 and 2 are running, fuses are placed across the dotted lines *1* and *2*. This connects phase A of screen motor No. 1 with the closing coil of the contactor through fuse *1*. The circuit is completed through fuse *2*, to phase B of screen motor No. 2. Since both screen motors are connected to the same power supply by means of switches *3* and *4*, current will flow from the A phase of No. 1 screen motor through the closing coil to the B phase of No. 2 screen motor, provided these motors are in operation. The contactor will then close, completing the circuit through the no-voltage release coils on the pump motors, thereby permitting them to be started.

With screen motor No. 1 operating alone, fuses are placed across lines *1* and *3*. Phase A of screen motor No. 1 is thereby connected through fuse *1* to the closing coil and back through fuse *3* to phase B of the same screen motor. If No. 1 screen motor is in operation, current will flow through the closing coil as outlined, causing the contactor to close, thereby completing the circuit through the no-voltage release coils of the pump motor starters and permitting either pump to be started. When No. 2 screen motor only is running, fuses are placed across dotted lines *2* and *4* to complete the circuit in a like manner.

If for any reason the power supply to the screen motor fails, the contactor will open and cause the no-voltage release on the pump motor control to trip, thereby shutting down the pumps.

Inasmuch as the current drawn by the contactor coil is comparatively small, 1-amp. fuses are used. It will also be noted that only two fuses are in use at any time, thereby avoiding possible danger from short-circuits. Single-pole switches were suggested in place of the fuses, but they were not used because of the possibility of some unauthorized person closing all of the switches at once and receiving a severe burn or shock.

LEE F. DANN.

Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

ELECTRICAL TESTING

How to Determine Accuracy of Watt-Hour Meters

The accuracy of watt-hour meters should be checked at regular intervals if reliable readings are desired. In these meters the speed of the rotating element is proportional to the load carried by the meter. Therefore, to test the accuracy of the meter it is necessary to determine whether the speed of the disk is correct for the load applied.

Constants.—The energy represented by one revolution of the disk of a watt-hour meter is called the "watt-hour constant," and this is the fundamental constant in nearly all meter calculations. This number is usually stamped on the disk or some other part of the meter.

Where instrument transformers are employed the meter commonly has a 5-amp. rating, the output of the current transformer secondaries at full load being 5 amp. The ratio of transformation is generally expressed as $n/1$. In this case the normal watt-hour constant of the 5-amp. meter must be multiplied by n. For example, with a 200-amp. transformer the ratio is 40 to 1, so the 5-amp. constant must be multiplied by 40. On high-potential primary metering installations where

both current and potential transformers are used, the 5-amp. constant must be multiplied by the product of the current and potential transformer ratios.

In this way, using the 5-amp. constant as a base, the watt-hour constant of any size of meter can be computed. When the full rating in amperes and volts is stamped on the nameplate, the true constant will in all probability also be given.

On large meters the gear mechanism, or register, records the total energy in the line in such a manner that the dial readings must be multiplied by a "dial constant," which may be 10, 100 or some other number. This constant is not used in checking the accuracy of the meter, but is needed only in reading the index on the dial.

There is another constant with which under normal conditions the maintenance men are not directly concerned—namely, the "register ratio." Since many meters of a given type have the same full-load speed, regardless of their rating, the gear mechanism must be arranged to record the energy correctly. This ratio may be expressed as the number of turns made by the disk shaft to one turn of the fastest moving dial pointer.

Testing.—A meter may be tested by means of a "rotating standard," which is simply a portable meter of known accuracy. To use this rotating standard, compare the revolutions of this disk with those of the meter being tested when both meters are connected to the same load.

As the factory maintenance engineer does not usually have rotating standards at his disposal, he must rely on his indicating instruments. With these and a stop watch he can make a thoroughly reliable test, unless there are large load fluctuations on the line. The method of carrying out this test is as follows:

A given number of disk revolutions are timed, preferably by means of a stop watch, although an ordinary watch may be used. Then the watt-hour constant multiplied by the number of revolutions equals the watt-hours. This result can be checked, after determining the power factor, by computing the watt-hours from the readings obtained from the indicating ammeter and voltmeter. Finally, the accuracy of the watt-hour meter should be determined only after taking the average of several tests. In all testing of this nature extreme care must be used in order to reduce the personal error to a minimum.

N. Cook.

Paterson, N. J.

How to Determine Power Factor With Slide Rule

Now that the slide rule is losing most of its mystery, some of the practical uses to which it may be put are interesting to know. It is often desirable to calculate the power factor of a circuit, a load, or a motor, when

it is not possible to get simultaneous readings in kilowatts, amperes and volts. Most formulas for finding power factor require the use of trigonometric tables; a slide rule, however, will do just as well and is handier to use.

For three-phase circuits, the power factor may be found by using a slide rule and the formula $(a - b) \div (a + b) \times \sqrt{3}$ = the tangent of the angle of which the cosine is the power factor. In this case a and b are either the readings of two integrating watt-meters or the single-phase readings from a polyphase wattmeter. The expression $(a - b) \div (a + b) \times \sqrt{3}$ may be replaced by reactive kva. ÷ kw. when the readings from a wattmeter and from a reactive kilovolt-ampere meter are available. The expressions just given may be solved with or without the slide rule, as desired, to compute the value of the required tangent.

In using the slide rule, the following procedure is required: Set the slide so that the end of the 45-deg. line or the tangent scale coincides with the end of the *D* scale. Then place the hairline against a number on the *D* scale corresponding to the tangent value previously found, and read off the angle on the tangent scale. Since the slide rule has no cosine scale but tangent and sin scales only, the sin scale has to be used. The cosine of an angle is equal to the sin of its complement or its difference subtracted from 90 deg. Therefore, subtract the angle already found from 90 deg. and with the slide in the same position, and the hairline placed against this complementary angle on the sin scale, read the sin value on the *A* scale. This number is the required power factor.

For tangent values below 0.9, the following method, although a little longer, will be found more accurate on account of the difficulty of obtaining accurate readings near the right-hand end of the sin scale, due to close spacing. For any angle, the sin divided by the tangent is equal to the cosine. Following the same procedure as before find the tangent value and read off the corresponding angle on the tangent scale; then on the *A* scale read the sin value of this angle (this is not the complementary angle) on the sin scale. Set the slide to divide this sin value by the tangent value already found and the quotient will be the power factor. Although this method may appear rather cumbersome and requires a long explanation, it will be found easy to apply with very little practice and the power factor can be worked out to within ½ per cent in less than a minute.

A few examples will illustrate the procedure. Suppose you are using a polyphase recording wattmeter to check the load on a motor and you want to know the power factor. Take two single-phase readings by disconnecting either the potential or the current coil, as most convenient, first on one phase and then on the other. We will say that the single-phase readings are 414 and 126 respectively. Substituting these values in the formula, $(a - b) \div (a + b) \times \sqrt{3}$ to find the

tangent, we will then have (414 — 126) ÷ (414 + 126) × 1.732 = 0.923, the required tangent. Now set the hairline at 923 on scale *D*, with the slide placed so that the scale ends coincide; the corresponding angle on the *D* scale will be 42 deg. 40 min., approximately. Since 0.923, the value of the tangent, is over 0.9 use the first method. Subtract 42 deg. 40 min. from 90 deg.; this gives 47 deg. 20 min. Using the sin scale and the *A* scale, read the sin value of the angle, 47 deg. 20 min., which is found to be 0.735. This value of 0.735 is also the cosine of 32 deg. and 40 min. and is the required power factor.

Again, if the average power factor of a load is required for say a month from the readings of two integrating wattmeters, which are 72,850 kw.-hr. and 43,710 kw.-hr., respectively, substituting in the formula (72,850 — 43,710 ÷ (72,850 + 43,710) × 1.732 = 0.433, the required tangent. Set the hairline against 433 on scale *D*, as before, and read 23 deg. 25 min., approximately, on the tangent scale. As 0.433, the value of the tangent, is less than 0.9 the second method is more accurate. On the *A* scale read the sin of the angle, 23 deg. 25 min., which will be about 0.397. Divide 0.397, the value of the sin, by 0.433, the value of the tangent. This will give 0.917, approximately, as the power factor required.

When it is necessary to find the power factor from the readings of the wattmeter and a reactive kilovolt-ampere meter, all that is necessary is to divide the reactive kva. reading by the kw. reading, the quotient giving the tangent of the angle of which the cosine is the power factor. Then proceed as in the examples given, according to whether the tangent value is above or below 0.9.

J. H. GALLANT.

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Belleville, Ontario, Can.

How to Make Rheostat for Testing Fields of D. C. Motors and Generators

Testing the fields of direct-current motors and generators frequently requires a rheostat of such capacity in the first few steps that only a comparatively expensive commercial rheostat will suffice. To meet this need for a suitable and inexpensive rheostat in an Eastern manufacturing plant, one was built, mostly with material on hand, as described below.

The 230-volt motor for which this rheostat was first designed has a shunt resistance equal to 36 ohms, and is of the adjustable-speed type, 300 to 900 r.p.m., rated at 48 hp. for 1 hr. with a rise of 50 deg.

The rheostat has a range from 0 to 100 ohms and from 100 to 200 ohms, adjustable in 10-ohm steps, with a current capacity of 5 amp. on the first step and 1.69 amp. on the last step. The resistance consists of ten 10-ohm wire resistance units and one 100-ohm unit,

Resistance and Load Data of Rheostat Used for Testing D. C. Motor and Generator Fields

Step No.	Resistance Ohms	Rating Watts	Load	
			Amp.	Watts
1	10	270	5.00	250
2	10	[illegible]	4.10	168
3	10	144	3.50	122
4	10	108	3.03	92
5	10	[illegible]	2.68	72
6	10	75	2.40	58
7	10	60	2.17	47
8	10	45	[illegible]	40
9	10	45	[illegible]	34
10	10	45	1.69	29
Extra	100	361	1.69	[illegible]

which is cut in or out by a single-pole, single-throw switch. Single-pole switches are used to cut the rheostat out of the motor field circuit. In order to obtain the required capacity in the various steps at the least cost, the resistance units were purchased in the sizes shown in the accompanying table. It will be noted that the load on each unit is always considerably within its rated capacity.

The resistance units were mounted on an asbestos wood block, ⅜ in. thick, which is secured to the back of a maple panel. The arm and contact points were taken from an old, discarded rheostat.

The maximum normal shunt field current within the capacity of the rheostat is 9.75 amp. for a 115-volt motor, 6.75 amp. for a 230-volt motor, and 5.75 amp. for a 550-volt motor. Any shunt or compound wound motor having a normal field current not exceeding the values given can be safely handled, even on the first step of 10 ohms.

The cost of the material used was $16.40, and the cost of labor for assembling was $7.50.

Assistant Chief Engineer,
Gurney Elevator Co.,
New York, N. Y.

J. M. WALSH.

Checking Up and Servicing Electrical Troubles

A system of keeping a graphic record of trouble calls throughout our plant is based on making each trouble call count for so many points according to the importance of the operation and the time lost in the delay. The plant is divided into sections as, for instance, the hot mill, the annealing rooms, the tin house, the assorting room, and the like. One electrician is in charge of each department and his sole duty is to go over the electrical apparatus in his division and keep it in first-class condition. Each morning he is given the reports from the trouble shooters for the previous 24 hr. so that he can follow up all jobs.

The "Troublegraph" is plotted on a large sheet, the number of trouble calls received during the past 24 hr. being represented by a red line, which rises and falls in accordance with the amount of trouble. Hence, our slogan is, "Keep the red line down!" Every man in charge of a department has his name and department listed on this sheet and every morning the number of points chargeable to his department are marked up. If there has been no trouble his space is marked "0."

A meeting is held once a month in which every man participates, suggestions being offered by the men for improving operating and safety conditions throughout the plant. The "red line" also comes in for discussion, the men whose departments were responsible for running the red line up being asked to give an explanation and urged to do better in the future. Many things are brought to light in this manner, which otherwise might be missed. Careful inspection is made on all work done by the men, whether it is repair work or new work. Since instituting this system, our service troubles have fallen off one-half or more.

In order to give prompt attention to electrical troubles throughout the plant a 20-station annunciator has been installed in the shop, with push buttons to operate the annunciator located in almost every department of the plant. When a trouble shooter is wanted in any part of the mill, the annunciator indicates the location of the button station and very little time is lost in getting on the job, thereby saving the time and trouble of sending a man to the shop every time an electrician is wanted. The trouble shooter can also answer the call by pressing a button in the shop which lights a lamp at the button station, signifying that the ring has been heard.

We are planning to install red signal lights on the top of the main drive gears of each of the six 1,000-hp. drive motors with which the hot mill of the tin mill is equipped. There will be two whistles placed at these motors so spaced that either whistle can be heard in any part of the mill. This system is to be used in calling the proper attendant to any motor that needs attention.

C. H. Smith.

Chief Electrician,
Sheet & Tin Plate Division,
Bethlehem Steel Co.,
Sparrows Point, Md.

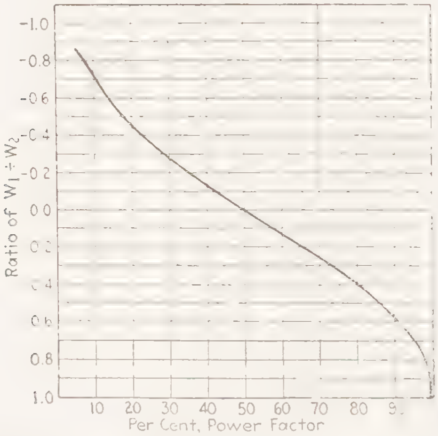
Determining Power Factor With Watt-Hour Meters

It is well known that the power in a three-phase circuit can be measured with a polyphase watt-hour meter having two potential and two current coils, or by two single-phase watt-hour meters. It is assumed that in the usual industrial installation, the load circuits are ungrounded. However, the necessary modifications can

be made and the results obtained will not be affected when the following method is used.

Accordingly, it follows that the variation in the energy measured by the separate elements of the meter will depend entirely upon the power factor of the circuit. A very good example of this is a load having exactly 50 per cent power factor; if two single-phase watt-hour meters are used, the disk of one meter will stand still. The general formula for the energy of a three-phase circuit is: Total watt-hours $= W_1 + W_2$, where W_1 and W_2 represent the registrations of the separate elements of a polyphase watt-hour meter or the individual registrations of two separate single-phase watt-hour meters.

The test for power factor when the meter disks are visible may be conducted as follows: If the watt-hour meter is of the polyphase type, take the time of say ten



By means of this curve the power factor expressed in per cent may be found from the values registered by the individual elements of a polyphase watt-hour meter.

revolutions of the disk without any change of connections, calling this result Tw. Then disconnect one of the voltage elements and again take the time for ten revolutions. The last test will probably take a longer period of time, or T_1. Knowing the meter constant and if the time is taken in seconds, the total load Wt in watts may be calculated by the formula: Watts $= (3{,}600 \times K \times R) \div S$, where $K =$ watt-hour constant, $R =$ number of disk revolutions, and $S =$ time in seconds required for R revolutions.

The registration of the single element W_1 may now be obtained as follows: $W_1 = Wt \times (Tw \div T_1)$. The energy registered by the other element, W_2, may be found by using the formula $W_2 = Wt - W_1$. The

power factor of the circuit may now be obtained as follows: Find the ratio of W_1 and W_2 by dividing the smaller by the larger value and substituting this value for X in the following equation: Power factor in per cent $= 100 \times \frac{1}{2} \times \sqrt{(1 + X)^3 \div (1 + X^3)}$. For quicker determination of the power factor consult the accompanying curve, which only requires that the value of the ratio be calculated.

In connection with the use of the power factor formula, a word of caution should be noted. When the power factor is less than 50 per cent one of the meter elements will move faster when operating alone, while the other will reverse. In fact, if the power factor is exactly 50 per cent one of the elements will not revolve when the other is disconnected. If a polyphase meter is used for the test, equation $W_2 = Wt - W_1$ still holds good, except that if one element reverses its rotation, the value must be considered negative or minus. The equation would then become $W_2 = Wt - (-W_1)$ or $W_2 = Wt + W_1$, which shows that the element W_2 would speed up when operating alone. Accordingly, the ratio of the smaller value of W divided by the larger would be negative, as is shown on the ordinate of the curve.

Using two single-phase watt-hour meters it is not necessary to calculate the load in watts as it may be obtained directly from the timing of, say, ten revolutions of each meter. Since the speed is directly proportional to the load the following relation is obtained: $W_1 \div W_2 = T_2 \div T_1$. Likewise, the same number of revolutions of the faster moving element multiplied by its load equals the time of the slower moving element multiplied by its load. The fact should also be remembered that in using two separate, single-phase meters, W_1 and W_2 are obtained separately from each meter. These values could be determined from the formula $W_2 = Wt - W_1$, by taking the time of each element separately. It might also be done as a check with a polyphase meter, although this is not actually necessary.

When the meter disks are not visible, the following procedure is required. This is not a frequent condition, but if encountered it will be necessary to take the time required by the meter dial to traverse one division of the smallest dial and calculate the actual load according to the formula: Kilowatt-hours per hour = (kilowatt-hours ÷ time interval in minutes) × 60 = kilowatts. This must be done as described previously for the visible type meter disk when one element is disconnected. However, in this case, we can modify the test very materially; as we have observed the time for the same watt-hour or kilowatt-hour registration, the time will be a measure of the load. The relation $W_1 \div W_2 = T_2 \div T_1$ is applicable; that is, the ratio of the element registrations may be obtained by dividing the lesser time by the greater and obtaining the power factor directly from the curve, or by the power factor formula as previously given.

In all of the foregoing tests it has been assumed that we are particularly interested in obtaining the power factor value. It is, however, readily possible, if the actual watt demand and power factor are known, to calculate the kilovolt-ampere demand by the formula, kva. = kw. ÷ P.F.

The description of this method of determining power factor has been given in considerable detail, but its application is exceedingly simple. Advantages that recommend its use are as follows:

(1) No voltmeters or ammeters are required.

(2) No inherent error is involved in calculating the kilovolt-amperes due to instrument errors and the difficulty of taking readings on an unsteady load.

(3) The method is inherently accurate, as the watt-hour meter is an accurate instrument.

(4) When a watt-hour meter is already installed, no additional test instruments of any kind are required.

This method has been used for a number of years in actual practice with excellent results. The writer, when an employe of a public service corporation, had occasion to observe that the customer's representatives were much more agreeable to having tests for power factor made in this way than with the many instruments, instrument transformers and complicated connections that would be otherwise required.

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Ground Detectors for Use on Low-Voltage Systems

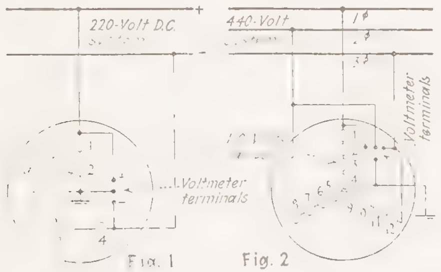
While working in a certain shop a great deal of difficulty was experienced with grounds on both the 220-volt d.c. and the 440-volt a.c. systems, because there was nothing to indicate when a line became grounded. This led to the installation of two ground detectors made up of lamps as shown in Figs. 1 and 2. These detectors were placed on the end of the switchboard in the power house.

On the 220-volt d.c. system four 110-volt lamps were connected in series across the line. If 220-volt lamps are used only two would be required in series. Between lamps *2* and *3*, as shown in Fig. 1, a ground tap was made. When the system is clear of grounds the four lamps will burn equally bright at one-half voltage. If the negative line is grounded lamps *3* and *4* will cease to burn, while lamps *1* and *2* will burn at full voltage. A high-resistance ground will show up as an unbalanced condition in lights *1* and *2* against lights *3* and *4*.

For the convenience of the electrician a portable test box was made with four lamps connected the same as the ground detector in Fig. 1. This box was connected to the line by means of a two-conductor cable with Bull Dog connectors at the ends so that they could be quickly and firmly clamped to the busbars in any fuse box on

the system. The ground wire was connected to the fuse box, which was metallic and permanently connected to ground. See Fig. 3 for illustration of these connections.

A few trouble cases will best illustrate the operation of this detector. One day the operator in the power house noticed that lamps *3* and *4* burned brightly, showing that the positive line was grounded. His instructions were to locate the ground by opening the switch of each feeder panel, one at a time, to see if the four lamps would burn with equal brilliancy at one-half voltage. When he opened the switch on feeder-panel No. 3 (Fig. 3) this condition was not fulfilled. The operator immediately knew that the ground was located on some line connected to this feeder-panel. He at once notified



Figs. 1 and 2—Connection scheme for a ground detector using lamps.

In Fig. 1 is shown an arrangement using four 110-volt lamps for indicating grounds on a 220-volt system. Fig. 2 shows the connections for a detector used on a 440-volt, three-phase system.

the electrical foreman who assigned an electrician to locate the ground. Feeder-panel No. 3 had six fuse boxes each provided with a cutout switch, and all lines connected to these boxes were fused. In this manner a ground in any conduit or machine can be eliminated by disconnecting the line from the feeder box by pulling the fuse.

The electrician proceeded with the elimination process by going to fuse box *3-A* (Fig. 3). After connecting the test set to the fuse box and noting the difference in brilliancy in the lamps, he opened the disconnecting switch. This did not affect the condition of the lamps as lamps *3* and *4* still burned bright. Immediately he knew that fuse box *3-A* was clear of grounds. After connecting the test set to fuse box *3-B* he found that when he opened the disconnecting switch instead of lamps *3* and *4* burning bright and lamps *1* and *2* not burning at all, the four lamps burned with equal brilliancy at half voltage. This showed that the ground was located on one of the six lines which were connected to this box.

The next step in the elimination process was to test the six different circuits by pulling a fuse on each

positive line in turn and closing the disconnecting switch to see if the four lamps burned with equal brilliancy. When the fuse on circuit No. 5 was pulled and the disconnecting switch closed, instead of *3* and *4* burning bright, the four lamps burned the same. This showed that the ground was located on the positive side of circuit No. 5. The electrician immediately replaced the fuse and disconnected the electric equipment at the other end of this circuit. He then noted that lamps *3* and *4* on the test set continued to burn bright-

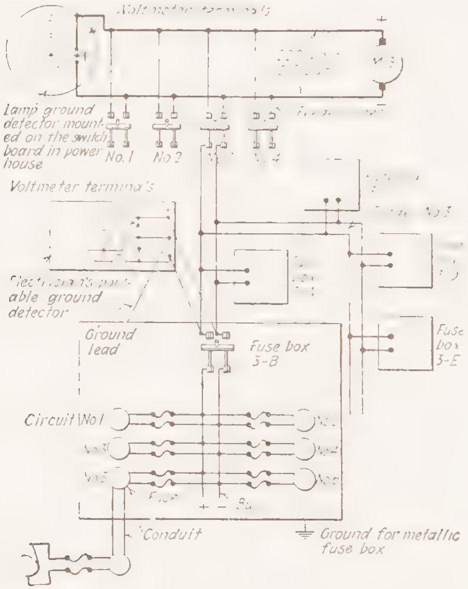


Fig. 3

Figs. 3 and 4—Steps in locating a ground on a feeder supplying many circuits.

By means of the power house ground detector the ground was found to be connected to No. 3 feeder as shown in Fig. 3. By testing with the portable detector connected as shown, the ground was located on circuit No. 5. Fig. 4 shows how detectors may be used in substations that are tied together.

ly. It was evident that the ground was between the fuses and the cutout switch at the motor. This also indicated that the positive wire was grounded in the conduit, which was true.

Another case of trouble that the operator noticed was that lights *1* and *2* burned very bright for a few minutes, but two or three minutes later lights *3* and *4* burned very bright. This indicated that the ground must be in some motor that was periodically reversed.

This condition continued for several hours. The ground was found to be on feeder panel No. 1. All of the motors connected to this feeder operated continuously in one direction with the exception of the motors on a crane. It was plain that the ground was on one of the motors or the wiring of this crane. It was found that the armature trolley wire on the bridge which supplied power to the armature leads of the hoist motor was grounded.

During a third case of trouble, lamps *3* and *4* would

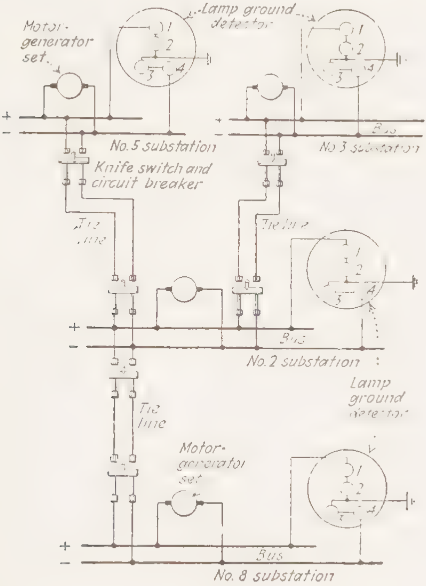


Fig. 4

burn very bright for a short time. For a period of approximately ten minutes the condition remained normal, then lamps *3* and *4* again glowed bright for a few minutes after which they became normal. Two hours later they again glowed brightly for a few minutes and during this time the operator was able to determine that the ground was on feeder No. 5. By analyzing the type of work done and the time of operating the equipment on this feeder line, it was decided that the ground must be on the electrical equipment that operated the turntable at the locomotive roundhouse. Investigation proved this assumption to be true.

This type of ground detector was also installed on the three-phase, 440-volt, a.c. system. Twelve 110-lamps were connected in three groups of four each in series, connected star across the three-phase lines, the center connection of the star being grounded as

shown in Fig. 2. This placed eight lamps in series across each of the three phases. Half as many 220-volt lamps could have been used if desired. When the three lines were clear of grounds the 12 lamps would glow equally bright at half-voltage.

For example, let us assume that phase No. 3 became grounded. Under this condition lamps *9*, *10*, *11* and *12* would not burn, while lamps *1* to *8* would burn at full voltage. For the electrician's use we made up a portable test box to connect to the fuse box, when testing for grounds on the a.c. system. This box contained 12 lamps connected the same as in Fig. 2. Bull Dog connectors were used on the leads so as to facilitate connections.

Before installing this detector, phase No. 3 had a ground which we were unable to locate. When the ground detector was connected, lamps *9*, *10*, *11* and *12* did not burn at all while the rest burned bright. The first step in the process of elimination was to test out each feeder. This test did not change the condition of the lamps, which indicated that the ground was not on any of the feeder lines. We eliminated the motor-driven exciter by using a turbine-driven exciter, but still the ground remained. Alternately the four turbine-driven generators were taken off the line, but we were unable to locate the ground. Our next step was to disconnect the three-phase side of the two auto-transformers which were connected open-delta across the line for starting a large m.g. set (this being the only m.g. set directly connected to the bus). Immediately the 12 lamps glowed equally bright at half-voltage, thus indicating that this auto-transformer was grounded.

On another case of ground trouble, lamps *5*, *6*, *7* and *8* went out and the rest of the lamps burned bright; then lamps *1*, *2*, *3* and *4* were extinguished and the remaining lamps burned bright. Tests at the power house indicated that this ground was on the feeder supplying power to the scrap-yard crane, which was driven by three-phase, a.c. motors. Immediately we knew that the switching of the ground from one phase to the other was due to the switching of the primary leads on the motor when reversing the direction of rotation and, therefore, the ground was quickly located.

In conjunction with this type of ground detector, a daily check with voltmeter showed up a great many high-resistance grounds. Each detector was provided with terminals so that the voltmeter might be quickly attached to the board. On the d.c. system the normal voltmeter reading from either line to ground was 110 volts, while on the a.c. system it was 220 volts. This would be true if the line voltage were 220 and 440 volts respectively.

On one occasion the voltmeter read 140 volts from the positive bus to ground. This indicated that there was a high-resistance ground on the negative line. When the voltmeter leads were switched to the nega-

tive line the voltmeter read only 80 volts. This sustained our belief that a high-resistance ground existed on the negative side. As an aid in eliminating high-resistance grounds the test boxes were equipped with voltmeter terminals so that the electricians could connect the voltmeters to the test box and determine when he had eliminated the high-resistance ground.

This ground detector will work just as efficiently on a large d.c. system that is tied together as shown in Fig. 4. Such a system would likely be used in a large industrial plant. Let us assume a ground appeared on some line connected to substation No. 8; the operator in substation No. 2 sees that lights *3* and *4* are burning bright. Assume that the operator opens the tie line to substation No. 5; lamps *3* and *4* still burn bright. He then knows that the ground is not on the feeders radiating from this substation, and hence opens the tie line to substation No. 8. Immediately the four lamps glow equally bright at one-half voltage; this shows that the ground is on some of the feeders in sub-station No. 8. The operator in substation No. 8 must then be notified and he in turn will locate the feeder which is grounded and inform the electrical foreman. The responsibility for reporting grounds rest upon the station operator, who can generally be depended upon to make a complete report of any ground that might appear and how soon it was cleared.

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Determining Resistance of Ground Connections

Poor electrical grounds are a source of trouble that is often overlooked by industrial operators as well as by many others. This subject of "grounds," although an important one, is seldom mentioned in the magazines and the textbooks that I read, although faulty grounds are the cause of many men being either killed or burned by coming in contact with electrical apparatus which is either poorly grounded or which is not grounded at all.

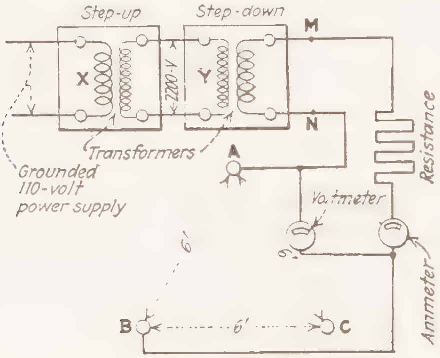
In the plant where I was employed last summer, considerable trouble was experienced due to surges. I was detailed to find the cause of this trouble but, before testing the line, I decided to read General Electric Instruction Book No. 85607A concerning oxide film lightning arresters, which book reads in part as follows: "In all lightning arrester installations, good, permanent, low-resistance grounds are essential for the satisfactory operation of the arrester. The efficiency of the best arrester design is defeated by a poor ground connection which causes a loss in protection and, ultimately, damage to apparatus. The greater the importance of the service, the greater is

the need of good grounds, and a regular system of testing and inspection should be put into practice."

A search for the trouble on the job assigned to me soon revealed the fact that a lightning arrester was connected to a poor ground.

The resistance of grounds should be tested at least once a year and, if the grounds are connected to a pipe which is driven into the earth, the inspection should be made during the dry season of the summer, for the resistance is highest when the soil is dry. The ground connection should never be put where it will be under shelter, unless it is to be kept damp by artificial means.

In most soils satisfactory grounds can be made by driving three galvanized iron pipes into the ground for a distance of about 8 ft., and then the earth should be



The resistance of the different pairs of grounds in series is determined by measuring the voltage drop across them.

When the series resistance of all the different pairs of grounds has been ascertained, the individual resistance of each ground can be determined as explained in the text.

salted for a distance of about 4 ft. around the pipe. The pipes should be placed at least 6 ft. apart, in this case forming the corners of an equilateral triangle. The pipes should be connected together with lugs so that they can be taken apart, if necessary, for inspection. When the pipes in the ground are 3 ft. apart or more, a satisfactory test can be made for the resistance of the sum of any two individual ground resistances, after they are connected in series, as indicated in the accompanying sketch.

By using a transformer to supply the test current, we have available a test current which is well insulated from the ground, for the secondary side of the transformer has no connection with the primary side. In this case we use two 110/2,200-volt transformers, but, if 2,200 volts had been available, only one trans-

former would have been used. One of the two terminals on the step-down side of the transformer marked Y was connected to one ground as indicated in the illustration. An ammeter and a resistance of about 5 ohms were connected in series with the other line leading from the step-down side of the transformer Y. The voltmeter was connected so that it would indicate the voltage drop between the two ground terminals A and B.

The resistance of each ground can be determined as follows:

Assume that the sum of the two individual resistances of the grounds, A and B, is to be determined. A fixed resistance of about 5 ohms should be used to limit the flow of current to about 5 amp. Assume that the voltmeter reads 85 volts and the ammeter reads 5 amp. Then, resistance (R) = volts divided by amperes $= 85 \div 5 = 17$ ohms, which is the total resistance of A and B connected in series.

When determining the resistance of $B + C$, say the voltmeter reads 78 and the ammeter reads 6 amp. Then $R = 78 \div 6 = 13$ ohms, the combined resistance of B and C connected in series.

Also, assume that when connected to $A + C$ the voltmeter reads 72, and the ammeter reads 8 amps. Therefore, $R = 72 \div 8 = 9$ ohms, the combined resistance of A and C when connected in series.

The resistance of A can then be determined as follows: $(A + B) - (B + C) = 17 - 13 = 4$. Therefore, $A - C = 4$. The resistance of $A + C$ was determined as 9 ohms. Then $(A + C) + (A - C) = 9 + 4 = 13$ ohms. Consequently, $2A = 13$ ohms, and $A = 6.5$ ohms.

By the same method of procedure the resistance of B is found to be 10.5 ohms, and the resistance of C, 2.5 ohms.

The total resistance of A, B, and C in parallel is determined as follows:

$R = 1 \div [(1 \div A) + (1 \div B) + (1 \div C)]$. Substituting the values of A, B, and C in this formula we find that $R = 1.55$ ohms.

In the event that the resistance of the ground is very low, a standard 110-volt, a.c. voltmeter will be difficult to read when connected as shown in the illustration. So, in this case, the voltmeter should be connected between M and N, and will then indicate the voltage drop across the ground resistance and the fixed resistance connected in series.

In actual operation a faulty ground is generally much more than 6 ft. from the ground pipes. The result is that the ground resistance in actual operation is greater than indicated by the test, for the resistance through the earth varies approximately as the cube of the distance between the ground terminals. By actual test, when two ground connections are used instead of one, and these grounds are set in the earth 1 ft. apart, their combined resistance in parallel is about 10 per cent less than if one ground were used.

Should these grounds be placed 10 ft. apart instead of 1 ft., their combined resistance in parallel would be about 47 per cent less than if one ground were used.

In order to insure a reliable ground, at least two ground connections should be used and spaced at least 6 ft. apart. Do not locate ground connections beside creosoted poles. When pipes are used, they should be sunk into the earth to a minimum depth of 6 ft. The resistance of ground connections during dry weather should not be more than 15 ohms.

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C. H. FUNDERBURG.

Testing Equipment for Fuses and Lamps

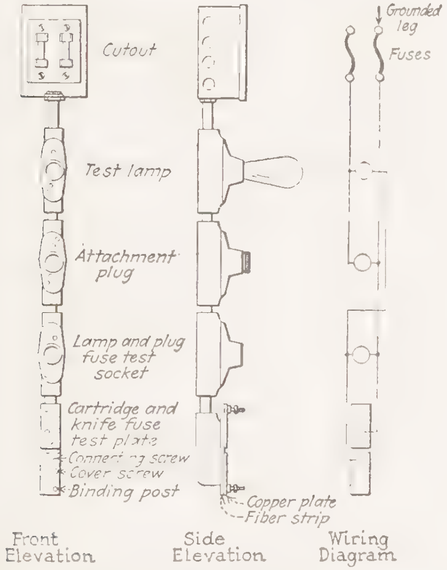
In many small industrial plants the only available equipment in the maintenance shop for testing fuses and lamps to see if they are burned out, or for detecting shorts or grounds on equipment, is a convenient cutout and the electrician's old stand-by, the weatherproof socket spliced to a piece of lamp cord. Even in plants that have excellent facilities for testing large motors, testing in the shop of fuses or lamps from stock is done with the above-mentioned makeshift connections.

Both time and money are wasted when valuable equipment and operators stand idle, because general maintenance men, lamp cleaners or operators have replaced blown fuses or burned-out lamps with bad fuses or lamps from the department stock. Then the electrician is sent for to repair supposedly defective equipment while men and machines stand idle. Such delays can be prevented if testing facilities are available for those whose duty it is to replace blown fuses or broken lamps.

For this reason in one plant I made up some inexpensive testing outfits of conduit fittings, like the one illustrated in the drawing. It was so convenient to use that it prevented untested lamps or fuses from being used for replacement. The lamp and plug fuse testing socket was made by removing the shell of a receptacle and hammering the threads flat, using a piece of ½-in. pipe for an anvil. The lamp or fuse could then be pushed into the socket without being screwed in. This eliminated labor on the part of the person using it and encouraged its use. By substituting a brass disk about ¾ in. in diameter for the spring contact in the base of the receptacle, and raising this disk by placing fiber washers under it so as to make the socket shallow, single-contact bayonet-base lamps used in automobiles and candelabra-base lamps used as indicating lamps could also be tested.

The test plate for cartridge and knife fuses is made by securing two copper or brass plates to a piece of ¼-in. fiber about 6 in. long and separating the two plates about ⅛ in. Care must be taken to countersink

the heads of the cover screws so that they will not come in contact with the plates and cause a short-circuit across the device. Fuses ranging in size from instrument type to those of 200-amp. rating can be tested by placing them across the plate. Larger, or high-voltage, fuses can be tested by placing a screw-driver or any handy piece of metal on one of the plates and touching it to the fuse end. Double-contact, bayonet-base lamps can also be tested on the plate. By placing binding posts on the ends of the test plates, leads may be taken off for testing for shorts or grounds when repairing small apparatus at the bench. Ordinary test leads that are permanently fastened at one end have a very short life, as every electrician knows, and usually when one is in a hurry to use them



Here is a testing outfit that is made of standard conduit fittings and will facilitate the testing of lamps, fuses and other equipment.

they are broken. By the use of these binding posts any scrap wire around the shop can be quickly attached to make an improvised pair of test leads whenever occasion demands or for an emergency.

By using a 50- or 60-watt lamp as a test lamp, all types of lamps can be tested from a 2 c.p. auto-lamp to a 200-watt lamp. There will be no danger of burning out the small, low-voltage lamps when they are tested on 110 volts in series with the test lamp. The larger lamps, of course, will burn only very dimly when in the test socket. In wiring be sure to bring

the hot leg to the test lamp and the grounded leg to the testing devices, to prevent accidental shorts from grounds.

The material required and the cost of this testing device is as follows:

MATERIAL	COST
1 3-in x ½-in x 5 in. outlet box [illegible]	[illegible]
1 2-wire, 30-amp. cartridge fuse cutout	.40
2 15-amp cartridge fuses	.20
3 Type C conduit fittings, ½ in.	1.11
1 Type E conduit fitting ½ in.	.27
3 Conduit fitting receptacles	.81
4 ½-in x 2-in nipples	.20
1 ½-in locknut	.01
1 ½-in bushing	.02
8 ft. No. 14 R. C. wire	[illegible]
FOR TEST PLATE	
1 piece of fiber 1¼ in. x 1¼ in. x 6 in.	.06
2 pieces of copper ⅛ in x 1¼ in. x 3 in.	.20
2 1-in [illegible] F. H. brass screws	[illegible]
2 8⁄32-in. brass battery nuts	.02
2 ¾-in., 6⁄32 F. H. brass screws	.02
2 ½-in., 6⁄32 F. H. brass screws	.02
2 6⁄32 hex. brass nuts	.02
2 ⅛-in. brass washers	.01
FOR TEST RECEPTACLE	
1 fiber washer ⅜ in. x 1 in.	[illegible]
1 fiber washer ⅜ in. x 1 in.	.05
1 6⁄32 F. H. brass screw (length will vary according to make of receptacle used)	.01
	$3.98

The amount of labor necessary for assembling the above at the bench will be one man for 1½ to 2 hrs. The amount of labor for installing the testing device will depend upon how far a line must be run to the place where it is being installed.

Elizabeth, N. J. WM. H. FREDERICKSON.

HEATING OVENS

Preheating Fuel Oil Electrically

The efficient combustion of fuel oil depends, to a certain extent, upon maintaining a constant fluidity of the oil at the burners, and the fluidity, in turn, depends upon the temperature of the oil. According to C. J. Carrigan, of the Phoenix Rolls Corp., Pittsburgh, Pa., two electrically-heated oil heaters are used for preheating the fuel oil used in their open hearth furnaces.

Each of these heaters consists of a cylindrical tank, 10 in. in diameter by 96 in. high, and 32 Westinghouse space heaters, arranged around the tank, heat the oil. The oil temperature is automatically controlled by means of a bimetallic thermostat mounted on the side of the oil tank, through a motor-operated snap switch

and a contactor. The oil, which is circulated by a motor-driven pump, enters the heater at the bottom and leaves from the top. The capacity of each heater is sufficient to heat 100 gal. of oil per hr. to 180-210 deg. F.

One of the chief features of this method is that the control apparatus keeps the temperature of the oil at the desired point without any attention on the part of the operators. By using these preheaters more efficient combustion in the open hearth furnaces is obtained, with a resultant saving in the cost of fuel.

INSULATION

Comparison of Insulation Resistance and Dielectric Strength

There seems to be confusion in the minds of some engineers as to the difference between dielectric strength and insulation resistance, as applying to electrical apparatus generally, and consequently there is some lack of appreciation of the value of making insulation resistance tests. We are all so familiar with the general practice of applying a high voltage for the purpose of testing motors, generators, transformers, and the like, that there is danger of overlooking the insulation resistance test, which gives results of equal and often greater usefulness. The writer offers the following comments as indicating the value of insulation resistance testing, both in addition to, and entirely apart from, the so-called high-potential or dielectric strength test.

All electrical insulating materials have two fundamental electrical properties: (1) Resistance to the passage of current, or insulation resistance, and (2) strength against breakdown under static or high-voltage stress, or dielectric strength.

Insulation resistance is expressed in ohms or megohms (millions of ohms), and is proportional to the thickness of a perfectly homogeneous insulating material and is inversely proportional to the area under test. For this reason the insulation resistance of a short piece of wire or cable is higher than that of a longer length. The values can be obtained quite readily by a number of different methods, one of the simplest and most reliable of which is the Megger method referred to below.

Dielectric strength is expressed in terms of the voltage at which the insulation punctures at some point, due to static stress, and can be measured only by testing to failure, similar in principle to the way samples of building materials are tested to destruction.

Now, insulation resistance is not ordinarily a measure of the voltage required to cause an actual breakdown or puncture of the insulation, although fre-

quently the insulation resistance test is a guide in this respect, as pointed out in the follownig paragraphs. But here is a fact which apparently few appreciate—a piece of electrical apparatus may successfully undergo a rated or specified dielectric strength test and still have relatively low insulation resistance. Low insulation resistance means increased current leakage to ground or to other conductors, and may be due to a number of causes, such as deteriorated insulation, or moisture, or both, or to dirt or corrosion at terminals. There is no way that the high-voltage dielectric test can indicate this condition without breaking down the insulation at some point, and even then, one only knows that the insulation was weak at that particular point. Furthermore, high-voltage testing does subject electrical equipment to serious risk of unnecessary and permanent injury, particularly old equipment where the application of high-voltage is "playing with fire," as far as trouble is concerned.

The so-called high-potential test is only part of the whole story in testing electrical apparatus, and actually, in many instances, it gives only a small part of the total information which one needs to know about the condition of a motor, generator or cable, and other apparatus.

It is common practice to apply high potential to new or repaired electrical apparatus. Experience has shown, however, that much electrical equipment will have a lower insulation resistance after a high-voltage test then preceding it, showing that something has happened which in all probability should not have happened. For example, if the insulation resistance of a repaired 50-hp. induction motor measures 2 megohms it is likely to measure as low as 1½ megohms or lower, after the motor has apparently successfully undergone a high-potential test. There is no way which the high potential will indicate this weakened condition, unless it is carried to the point where the apparatus breaks down entirely.

Applying a high-potential test is somewhat like suddenly dropping four or five times normal load into an elevator which, if the rope stands the strain, is expected to carry you and a normal load up eight or ten floors. How do you know whether or not you strained that rope to the breaking point when you applied the breakdown test? It might have been more to the point to inspect the elevator rope carefully for broken strands and as to how much it has stretched in its life, or would stretch under a given load.

There are many electrical operators who consider it worth while to make an insulation resistance test both before and after the high-potential test. Unnecessary breakdowns can be largely prevented by this method if a suitable standard is maintained, and to that extent the insulation test is a guide as to the amount of high voltage which it is safe to apply. It should be clearly understood that the high-potential test

is not replaced by the insulation resistance test on new or repaired apparatus. For example, $\frac{1}{32}$ in. of air space between a misplaced conductor and the frame of a machine may have good insulation resistance, but would readily break down under high voltage. However, such a failure usually is not a question of insulation, but of workmanship.

One will seldom risk the application of high voltage to a motor or cable, which apparently is all right, but which needs to be checked as to its condition. Manufacturers do not recommend this practice, and common sense will tell any one that the risk is unnecessary. It is here that the insulation resistance test is of greatest value; it does no harm to the apparatus being tested and it shows on a direct-reading scale what the condition of a motor or generator is relative to deterioration, moisture, or dirt accumulation. Insulation resistance varies considerably with temperature and humidity, but it takes very little practice on the part of an alert electrician to determine the condition of a piece of electrical apparatus, by means of an insulation resistance test. Regular tests and records are helpful in this connection. If a 100-hp. motor had 10 megohms insulation resistance a year ago and tests once a month or so have shown a falling off until now the insulation resistance is less than 1 megohm, there is ample warning that something is wrong. Your own general acquaintance with that motor will tell you approximately what and where the trouble is. The insulation test tells you that it is there. On the other hand, you may have another 100-hp. motor of the same type which has held consistently around 1 megohm for the past year, possibly up to 1.5 or down to 0.8 megohms, depending on specific conditions when the tests were made; but that machine is all right even though its insulation resistance is the same now as the first motor, which ought to be up to its own normal of 10 megohms. It is common practice to use 1 megohm as a safe working standard for much electrical apparatus, but actually the insulation resistance is relative, the same as a barometer or temperature reading is relative. The question is: Is it rising or falling?

In the hands of an alert, intelligent electrical engineer a megohmmeter or insulation-resistance measuring instrument is a powerful tool, and the results obtained far outweigh the money spent for it and time consumed in using it.

The practice of making insulation resistance tests has grown steadily during the past 10 to 15 years, and it would appear that the subject is destined to receive much more general attention and be given wider application. Particularly will this be true on account of the increasing necessity for uninterrupted service while plants are in operation, and the further economic advantage of preventing unnecessary trouble.

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Philadelphia, Pa.

T. B. Whitson.

Testing Insulation Resistance of Electrical Equipment

Direct-reading, insulation-resistance-measuring devices have many uses around an industrial plant. For example, they will show at a glance the condition of the insulation in light or power wiring, either at the time of construction or after the plant is in operation. The ordinary magneto will show short-circuits and direct grounds, but it does not show swinging or high-resistance grounds and, therefore, is not an entirely reliable instrument.

In testing motors, a device that will measure the insulation resistance is a practical necessity. Very often, while a motor is at rest, a ground cannot be found by the ordinary magneto or bank of lamps, for the reason that the coils assume their natural positions, while when running the internal stresses due to magnetic induction and centrifugal force will distort the coils and chafe the insulation, causing a so-called swinging ground. The writer has come across several cases of this kind which have been readily found with a Megger.

It has been the practice of the repair department in the plant with which the writer is connected, to test all coils as they are inserted in a motor during a rewinding job. This test shows the condition of the insulation not only between the coils and the core, but also between the layers of various coils.

In locating faults in compensators and controllers, the insulation-resistance method is the only means of locating a high-resistance path through mica, wood or fiber. Where water or metallic dust has caused a path between contacts, a carbon path of high resistance is usually formed in the insulation. It is difficult to locate this path by the ordinary magneto or lamp bank, but with a suitable megohmmeter the resistance can easily be measured.

According to the Standardization Rules of the A.I.E.E., the insulation resistance of a machine at its operating temperature shall be not less than that given by the formula:

Insulation resistance in megohms = voltage of terminals ÷ (rating in kva. + 1,000).

This rule should be adhered to as it is really low, and might be also considered arbitrary, especially on machines of high rating. For the sake of comparison, the accompanying table shows the safe limit as required by the above rule, and what I consider the safe limit from my experience with all types of equipment over a considerable number of years.

Although the A.I.E.E. formula may give an insulation resistance that will be ample under various conditions, from my point of view I feel that it is not infallible. For instance, when it is applied to a 75-hp. and a 200-kva. motor, both operating at 550 volts, the results are 520,833 ohms in the first case and 458,333 ohms in the latter.

In practice I do not consider it safe to attempt to place in service a motor that shows a reading below 750,000 ohms when the impressed voltage is 550 volts.

Not long ago, at our plant, a motor gave out and two coils had to be replaced. In order to do this, the top sides of ten coils had to be lifted and replaced. The windings were then dipped and baked for 48 hr. While still hot, a Megger test was taken and a reading of 600,000 ohms was recorded. Although this reading was not so high as expected, the motor was put back in service and lasted three weeks, when two coils in each of two phases broke down to ground. The motor was in a perfectly dry location and operated 20 hr. per day in two shifts of 10 hr. each.

In winding motors with a complete set of new coils, I try to get a reading of at least 10 megohms, cold test, for motors with open slots, and from 100 megohms to infinity, cold test, for motors with partially-closed slots.

In testing power wiring in conduit at our plant, nothing short of infinity on a 100 megohm Megger is accepted, with the wires disconnected at both ends, and four megohms when connected through service switches, compensators and motors. This is, of course, for a new installation operating at 550 volts.

Safe Values of Insulation Resistance

Machine Rating		A.I.E.E. Standard, Megohms	Writer's Standard, Megohms
Volts	Kva		
110	20	0.10784	0.25
220	20	0.21568	0.5
440	50	0.419	0.75
550	100	0.5	1.0
1,100	100	1.0	2.0
2,200	100	2.0	5.0
11,000	500	7.33333	20.0
22,000	1,000	11.0	Infinity

Compensators and a.c. controllers must show on test not less than 500,000 ohms; otherwise they are overhauled and re-insulated. The same, or a higher, reading is required on all d.c. control apparatus, for both 220 and 550 volts. Commutators, armatures and field coils are not considered in good condition when they give a reading of less than 750,000 ohms.

Following are the results of some tests made.

Test No. 1.—75-hp. motor, 1,800 r.p.m., three phase, 550 volts, direct-connected to a centrifugal pump. Reading when installed, 50 megohms; reading after two years' operation in a damp place, hot 9 megohms, cold 10 megohms.

Test No. 2.—35-hp. motor, 1,200 r.p.m., three phase, 550 volts, rewound. Cold test of each phase, open; to

ground, 8 megohms. Cold test when star-connected, 10 megohms. This motor had open slots and form-wound coils, varnished but not baked after winding.

Test No. 3.—10-hp., 1,800 r.p.m., three-phase, 550-volt motor with partially-closed slots, 55 turns per slot. Test of each coil as inserted, infinity. Test of completed winding after wedges were inserted, infinity. Test, both hot and cold after being dipped and baked, infinity.

Test No. 4.—50-hp., 1,200 r.p.m., three-phase, 550-volt motor. This motor had 18 defective coils removed and replaced with new ones. This necessitated lifting 10 extra coil slides which were afterward replaced. After being repaired, the motor was varnished and baked. When taken from the oven and allowed to cool, the Megger gave a reading of four megohms. After standing in the shop for three months, a reading of 800,000 ohms was registered, due to collection of moisture. An ordinary magneto gave no signal.

Test No. 5.—Four high-speed, 550-volt motors, ranging from 5 to 25 hp. were submerged, due to a blocked sewer. The motors were taken out of service immediately and placed in an electric oven. After being in the oven from 5 p.m. to 8 a.m. the following morning, they were taken out and tested. Three of them gave hot readings of 900,000 ohms, 1 megohm and 1.2 megohms respectively, while the fourth gave a reading of 250,000 ohms. As part of the mill was down, it was necessary to replace the motors as quickly as possible. Three of them were considered O.K., while a chance was taken on the fourth. Three of them stood up while the one showing the low reading went out three days after being put in service. A magneto was also used on this motor and gave no signal.

In locating swinging grounds I have found the insulation-resistance test to be indispensable. This type of ground is caused by chafing of the insulation against the core or slot sides, or by high-resistance carbon paths between conductors. Such grounds can be located by the "smoke-method," but this usually does considerable damage.

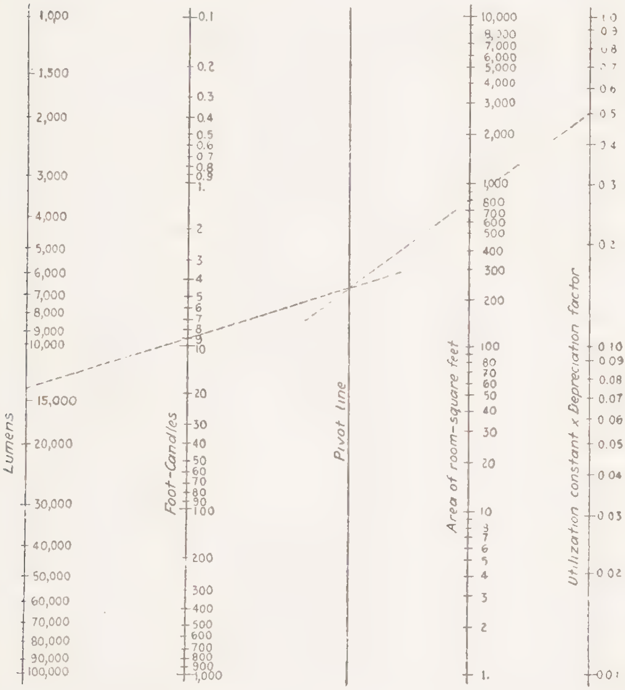
A high-resistance path between two contacts of an operating bar of a compensator or controller may not be revealed by testing with a lamp bank or a magneto, as the insulation is not sufficiently carbonized, but it will show up when full voltage is applied. Of course, where a fuse is blown and no trouble is found in the motor, a short-circuit is assured, but if a magneto or lamp bank shows a short-circuit, the trouble is mystifying to say the least. I have had several cases of this kind where the needle of the Megger would swing from zero to infinity in successive oscillations, on account of the path being broken and closed by the movement of minute particles of carbon during the passage of the current. This may sound theoretical, but the fact remains that this is what actually happens.

Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

H. E. Stafford.

Chart for Determining Lighting Requirements

The accompanying chart may be used for calculating illumination requirements when it is necessary to determine the utilization constant or co-efficient from the



This chart will simplify the calculations involved in laying out a lighting system.

Assume that utilization constant times depreciation factor=0.5; area of room=800 sq. ft.; foot-candles desired=9. Place a straight-edge so that it will intersect the area scale and the depreciation scale at the above values. Note the point of intersection with the pivot line. Then place the straight-edge so that it intersects the pivot line at the point noted, and the foot-candle column at 9; read the value of lumens required, 14,400, at the point of intersection on the lumen scale. The size of lamp to be used can be determined from the table.

character of the room to be lighted. The factors which must be taken into consideration are: color of walls and ceiling, mounting height of lamps above working plane, type of reflector, and distance between lamps. The accumulation of dirt and aging of the lamps make

it necessary to assign values ranging from 75 to 85 per cent for the depreciation factor. Tables covering lighting requirements may be found in the Standard Handbook for Electrical Engineers, or may be obtained from manufacturers of lighting equipment who supply literature concerning their reflectors and fixtures. Several states have codes which specify minimum requirements for intensity of illumination for different locations; consult the Standard Handbook for these.

Illumination Ratings of Mazda C Lamps

Size of Lamp in Watts	Lumens
50	450
75	865
100	1,260
150	2,040
200	3,100
300	4,840
400	6,700
500	8,750
750	13,900
1,000	19,300

To use the chart it is necessary to find the utilization constant and depreciation factor, which should be multiplied together. The area of the room is determined and a straight-edge placed on the chart so that it will intersect the Area scale and the Depreciation scale at the points corresponding to these values. Note the point where the straight-edge intersects the Pivot line (center scale). The straight-edge is then shifted so that it intersects the Pivot line at the point previously noted, and the Intensity in Foot-candles scale at the desired value. The intersection of the straight-edge with the Lumen scale, at the extreme left, shows the total lumens required. To find the lumens per outlet, divide the total lumens required by the number of outlets and note the value obtained for determining the size of lamps that should be used. The number of lumens to be obtained from various sizes of lamps will be found from the accompanying table above, which was taken from the Standard Handbook.

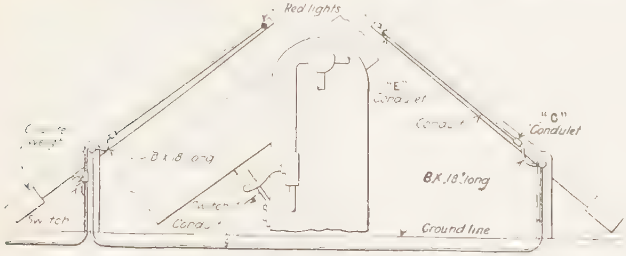
Rock Springs, Wyo. CHARLES F. CAMERON.

Warning Lights on Crossing Gates Controlled

Recently a pair of gates guarding a railroad crossing were fitted with one red light each. It was desired to have these lights controlled so that when the gates were

closed or down the lamps would be lighted, and automatically switched off when the gates were raised.

The wire on the gates was run in conduit and the joints in the underground conduit leading to the supply



When this crossing gate is up, the switch automatically opens and puts the red light out.

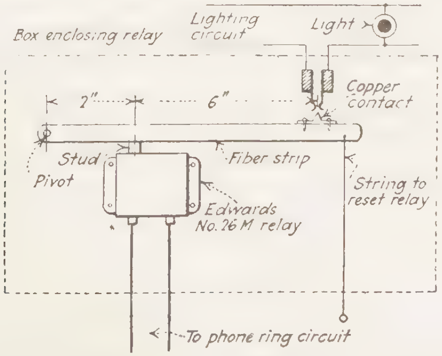
were carefully white-leaded to keep out water. For controlling the lights, a push switch such as is used in clothes closets, was installed as shown in the accompanying illustration. With this switch the circuit is open when the plunger is pushed in. Consequently, when the gates are dropped the lamp circuit is completed, but no current is used when the gates are up.

Chief Electrician,
U. S. Gypsum Co.,
Alabaster, Mich.

CHAS. A. PETERSON.

Relay for Lighting Lamp When Telephone Rings

Recently, we installed a telephone in a quarry, but there seldom was anyone near enough to hear the bell.



When the telephone bell rings the relay is energized, causing the lever arm to close the 110-volt circuit and light the lamp.

It was, therefore, necessary to provide some sort of signal that would be visible. The accompanying sketch

shows how a lamp was made to light whenever the bell rang.

The reset stud on an Edwards No. 26 M. relay was arranged to operate a fiber strip that was pivoted at one end. This stud has a travel of about ¼ in.; so the relay was placed in such a position that the travel of the stud was multiplied to ¾ in. at the copper contact which is attached to the fiber arm, as shown in the accompanying sketch.

Whoever answers the telephone pulls the reset string, breaking the contact to the lamp, and leaving the relay ready for the next call. It is evident from the sketch that there is no danger of the 110-volt circuit becoming grounded or crossed with the wires of the telephone circuit.

This relay has operated very successfully since its installation.

C. A. PETERSON.

Chief Electrician,
U. S. Gypsum Co.,
Alabaster, Mich.

MOTOR REPAIR

Causes and Remedies for Some D. C. Motor Troubles

Most d. c. motor troubles center around commutation and trouble is generally signalized by heavy sparking at the brushes.

Usually a small amount of sparking does not harm the commutator bars, but if it should, the cause of the sparking should be removed at the earliest opportunity. Small, noiseless, whitish-colored sparks on the edge of the brush are harmless. Sparking at irregular intervals, accompanied by a green flame and a hissing sound, is due to small particles of copper that have been disintegrated by continuous overheating, and will in a very short time cut a furrow around the commutator, and bits will adhere to the brushes. While an overload may in some cases cause excessive sparking, this is not usually the primary cause. Most reliable makes of motors are guaranteed for a 50 per cent, and with some makes 100 per cent, momentary overload. However, to allow an appreciable overload to remain, is a clear case of abuse, and the motor will naturally overheat.

Should there be sufficient overload on the motors to cause excessive sparking, some relief may be obtained by shifting the brushes, but the overload should be removed as soon as possible.

When the motor is not overloaded, we may look for the cause of sparking in the brushes. Shifting the brushes backward and forward may diminish sparking, or cause may be due to incorrect spacing of the brushes. In order to determine the correct spacing of the brushes, apply the following rule: Total number of commutator bars divided by number of poles equals the number of

commutator bars allowable between the edges of two adjacent brushes. When a good brush contact is being made, the commutator will assume a smooth, glassy surface with a rich chocolate color and the contact surface of the brush will be smooth.

In the event that the composition of the brushes is too soft or too hard, this fact will show itself in the surface of both the commutator and the brushes. If the surface of the brushes and commutator appears rough, and ploughed up, with specks of metal attached to the brushes, the latter may be immersed in a bath of hot petroleum jelly and boiled for a time, after which they should be thoroughly cleaned and dried. Fine sandpaper should be drawn between the commutator and each brush, with the rough side of the paper against the brush, to reseat it.

The commutator surface must be kept clean and glossy at all times. If it becomes roughened up as mentioned above this can be remedied by the use of a commutator stone or sandpaper held against the commutator with a wooden form. Care should be taken that all dust and abrasive material is removed before putting the motor into service again. Grease should be kept away from the commutator. Where this is hard to avoid, as in oil well drilling and pumping, a totally-enclosed motor is often used, which obviates this trouble.

Should the commutator become eccentric, nothing can be done for it while in service; it will be necessary to put the armature in a lathe and true up the commutator with a turning tool.

Other causes of sparking, such as grounds, open circuits and short-circuits, may be detected by test instruments.

Overheating may be due to several conditions, among which are poor bearing surfaces that cause excessive friction. Faulty lubrication is often the cause of this condition. The oil used in motors must be of the best quality, and adapted to the service conditions. Sometimes in a small plant, an oiler will use, regardless of its condition, old oil that may have been taken from the overflow of other machines. Where there are a large number of motors, it is economy to have a reputable oil company send in an expert to recommend the proper oil to use on each motor. Although this means that the oil company naturally expects that its products will be used, it has been my experience that this procedure will save trouble. This method of handling lubrication problems should likewise be applied to all mechanical equipment.

Shafting that is out of line, or tight belts will also cause heating, and the remedies are obvious.

All connections should be periodically tested out and tightened if necessary, especially in the case of motors that are mounted on slide rails for adjustment, where any looseness will set up a vibration. Should a motor by any chance be thoroughly wetted by rain, or through the bursting of a pipe, or other mishap, no attempt

should be made to run it, on the chance that it will dry out. It should be taken down and thoroughly dried out in the oven first. This may appear to be unnecessary, but it is cheaper than having coils burn out.

Hollywood, Calif. M. C. COCKSHOTT.

Causes and Remedy of Induction Motor Noises

Various noises due to the operation of induction motors, can be divided into three classes according to the cause, namely: magnetic, current, and windage.

The magnetic hum varies all over the sound scale from a faint hum to a high-pitch and noise or squeal. This hum is due in most cases to loose iron or to the vibration of the iron in the core that is being acted upon by pulsating fields of high frequency. This pulsating current depends on the frequency and flux density in the core, as well as on the shape, material, and dimensions of the magnetic circuit.

Magnetic noises can in most cases be distinguished by the fact that they remain practically constant at all loads. Such noises depend primarily on the frequency, a 60-cycle motor being more noisy than a 25-cycle machine.

The coil pitch affects the field form, which in turn also affects the magnetic noise. The ratio between the number of stator and rotor slots also has an important effect on the noise. With motors using large open slots, a well-designed metal or magnetic wedge will help to reduce the noise.

Skewing the rotor slots also helps to reduce the noise, the amount of skewing depending on the rotor and stator slot pitches. On the average the amount of skew is one rotor slot pitch.

Current noise sounds like a low growl or heavy rumble and in most cases is accompanied by vibration of the complete motor. This noise is due to unsymmetrical electrical or mechanical parts or circuits, and varies with the load, being loudest at starting and at full loads. It can be reduced by making any alterations found to be necessary upon testing for an unequal air gap and other mechanical variations and also by checking the coil grouping and connections for perfect balance.

Windage noises, which are caused by parts projecting out from the rotor and causing a whistling sound, may be due to slot cells being left open at the ends, or to deep rotor bars. Windage noise can be distinguished from current and magnetic noises by bringing the motor up to full speed and then suddenly throwing off the current. If the noise stops suddenly it is due to current or magnetic causes, as windage noises will continue as long as the rotor is moving, becoming lower in pitch and intensity as the rotor slows down.

A. C. ROE.

Renewal Parts Engineering,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

Care of Mica Segments in Commutators

The mica segments which insulate the commutator bars from each other occasionally need careful checking up, otherwise, poor commutation will result.

In the construction of a commutator the copper strips or bars are held together by a steel and iron cage, the bars being insulated from each other by mica strips.

The expansion and contraction of the copper bars has a tendency to push out the mica strips above the surface of the commutator. Should the mica be pushed out only a very little, the commutation of the motor or generator will be seriously affected.

In order to appreciate more fully the conditions under which a commutator functions, it is interesting to estimate just how frequently each brush makes and breaks contact with the commutator segments. This may be done by multiplying the revolutions per minute of the commutator by the total number of commutator segments.

It can readily be seen that contacts may be made and broken many thousands of times a minute. With even slight sparking at each make and break it does not take long for the bars to become burned and pitted. Sometime when the machine is not running, it may be interesting to observe by the use of a magnifying glass just what happens to the commutator bars when the brushes make a poor contact.

Again, from the foregoing it can also be seen that a commutator segment is in contact with a brush for a very small fraction of a second.

Some brushes contain a very fine grit which helps to grind away the mica whenever it moves above the commutator surface. The employment of these brushes is not the best method of overcoming the troubles caused by the high mica strips, for grit mixed with the graphite, dust, and a very fine oil mist makes a very good glaze material. This glaze is a good insulator, the electrical resistance of which is the cause of most of the heating of the commutator.

Undercutting, whereby the mica is cut away below the surface of the segments, is commonly practiced as a cure for high mica, and is so well known that little need be said about it here. However, the mica is often undercut too deeply with the result that carbon dust and dirt collects between the copper segments and may cause shorts. Trouble of this sort may be prevented by filling the space above the mica with one of the special cements or varnishes which are sold for this purpose. A cement is generally preferable, because as the cement wears out of the undercut space, the abrasive action keeps the commutator surface clean.

WM. L. WEBER.

Manager,
Acme Abrasive Co.,
Chicago, Ill.

Methods of Cleaning Motors

The question as to the best method of cleaning motor windings is an interesting and important one. It is also one on which there is some difference of opinion. I have used gasoline for cleaning windings, and alcohol for cleaning commutators and have never been able to find anything else that would clean motor windings of oil and sticky dust as well as they do.

I do not see any advantage in baking an oil-soaked motor; if it does anything baking would probably do harm because the oil that had partially solidified would be run into the cracks in the insulation by the heat. There might be some small advantage in heating the motor and then washing with gasoline, but I prefer to clean them cold. Of course, after thoroughly washing it would be a good idea, if a bake oven is handy, to give the winding a dip in baking varnish of high oil-resistant qualities. If the oven is not handy an air drying varnish can be had that is practically oil-proof. It is generally conceded by all authorities on varnish that the amber-or orange-colored varnish is the more oil-proof and the black varnishes are the more waterproof; that is, generally speaking.

The gasoline may be applied to the winding with a brush, a rag, or blow torch. It seems to me that dipping the motors in gasoline would be too expensive unless a large number of oil-soaked motors were to be cleaned.

GRADY H. EMERSON.

Birmingham, Ala.

Mixture for Protecting Commutator V-Ring Insulation from Oil

Three years' experience of a large repair shop in the use of a mixture of plaster of paris and dextrine as an oil resisting paste to prevent the disintegration of the varnish by oil on the outer V-ring insulation of the commutator, has shown that the number of armatures coming to the shop with grounded front V-rings has been greatly reduced.

The mixture used is composed of dextrine and plaster of paris in equal proportions, with just enough liquid shellac to give it the correct consistency. It should be made thick enough to be applied with a brush, although it is much thicker than paint and other substances usually applied with a brush. A coating about $\frac{1}{16}$ in. thick is applied to the front V-ring of the commutator.

MOTOR TESTING

Ammeter Indicates Single-Phase Operation of Motors

Recently I have noted several articles regarding the single-phase operation of the three-phase motors. Per-

haps the following experience may prove to be of interest to some of our readers.

One morning I was called to one of the mill departments by the department superintendent to find out why one of his motors showed such a high reading on the ammeter. As there were other motors running on the same line at the time we naturally thought of an overload at first, but found that all the connected machines were running normally. Then single-phase operation was thought of, but after the motor had been stopped it started again promptly; so the possibility of single-phase operation was dismissed for the time being.

There are three motors, one 50-hp. and two 20-hp. motors, running on the same branch circuit from the main distribution panel, all on one set of fuses, and under those conditions we were unable to understand the behavior of the ammeter. A few minutes later we had occasion to shut down all three of the motors and the cause of the trouble was immediately apparent when we attempted to start again—one fuse was blown.

Two of the motors had an ammeter mounted on their starters. One of these ammeters read high, while the other ammeter, which happened to be in a different phase, read low. What happened was that the 50-hp. motor had been started first; then the two 20-hp. motors had been started. During this operation the fuse had blown, but as the 50-hp. motor was running it supplied current for the others and enabled them to be started. As soon as all three motors were shut down it was impossible to start any of them. After the fuse was replaced the motors all started and ran perfectly, the ammeters showing normal readings.

Single-phase operation is difficult to detect with only one ammeter, unless it is arranged with a meter switch so that the current can be read in all phases. Two ammeters will immediately locate the trouble as will also two single-phase wattmeters.

If located in a quiet place single-phase operation can be detected by the peculiar hum of the motor, but in a noisy location no difference can be detected. A speed check is worthless as the change in speed is too small to be of any particular benefit in diagnosing the trouble. Of course, if the motor is left running long enough the coils will become unduly hot in one phase and thus disclose the trouble, but the insulation may be damaged.

Lee F. Dann.

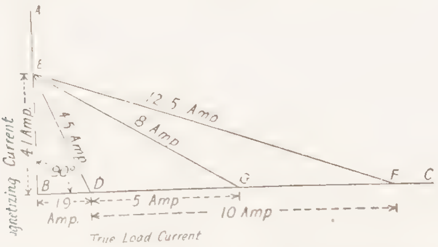
Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

Graphic Method for Determining Power Output of Induction Motors

A graphic method for obtaining a fair idea of the power required to drive certain machines has been found valuable, where no wattmeter was available, or lack of time did not permit its use. This method is not

claimed to be as accurate as the wattmeter method, but it certainly is more accurate than taking a current reading and multiplying by, say, 1 for 550 volts and calling the result the horsepower required. Consideration is taken of the motor losses and magnetizing currents even if they are a little high or low.

In finding the necessary data proceed as follows: (1) Note the motor rating with regard to horsepower, r.p.m. frequency, terminal voltage, and full-load current. Determine no-load current, that is, with the belt off or uncoupled, and line voltage. In the case of wound-rotor motors, the magnetizing current may be fairly closely determined simply by raising the brushes from the slip rings and measuring the primary current. (2) Take readings with an ammeter and voltmeter when the motor is driving its normal load. Make note of these readings and the corresponding line voltage. For good results, line voltage should be stable. (3) Approximate the efficiency of the motor to ascertain the losses, and also the power factor at full rated load.



The horsepower load may be determined from the current drawn by an induction motor, by means of a diagram like this, as explained in the text.

For example, take a 50-hp., 2,200-volt, 60-cycle, six-pole motor which was tested by this method and checked against its characteristic curves. Full-load current is 12.5 amp., no-load current is 4.5 amp., approximate efficiency is 85 per cent at full load, and approximate power factor is 94 per cent at full load. The losses are equal to $100 - 85 = 15$ per cent, or for this 50-hp. motor the losses would be 7.5 hp. The amperes per horsepower at full load equal $12.5 \div 50 = 0.25$, and for 7.5 hp. this would be $7.5 \times 0.25 = 1.9$ amp. A full-load power factor of 94 per cent at rated voltage and frequency equals the cosine of 20 deg.

Draw any right angle as shown in the accompanying diagram. Let the horizontal line BC represent true power in amperes and the vertical line AB represent the reactive component in amperes. Then the hypothenuse will represent the line amperes as read from an ammeter. Now with any convenient scale lay off, from the intersection of the two lines AB and BC on the horizontal line, 1.9 units, or BD, representing the loss in amperes. From D draw a line DE, 4.5 units long

cutting AB at E. BE represents the magnetizing current, ED is the no-load line current and BD is the motor losses at full load (all of these values are in amperes). From E draw a straight line, EF, 12.5 units long cutting BC at F. With a protractor, check angle BFE which should be close to 20 deg. Scale DF is equal to 10 units and represents 50 hp.; therefore 1 unit equals 5 hp., and we derive this constant, 5, to be used later.

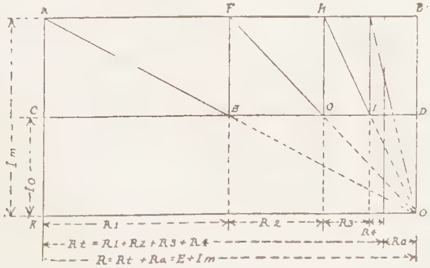
We are now ready to find the horsepower required to drive the load. The ammeter reads 8 amp. and the voltage is 2,200. From E draw a straight line EG 8 units long, cutting BC at G. Since BD represents motor losses and BG represents the total input, the input minus the losses equals the output or DG which equals five units. Multiplying these five units by the constant 5, which was found previously, gives 25 hp., or the output required to drive the lead. If the angle BGE is measured with a protractor, it will be found to be 31 deg., which corresponds to cos. 0.857 or the power factor of the motor when delivering 25 hp. For a table of efficiencies and other characteristics of induction motors, consult any good handbook.

New Westminster, B. C., Can. W. L. STEVENS.

Graphic Method of Computing Starting Resistance for D. C. Motors

In determining the amount of starting resistance required on each step of the starting rheostat, a convenient and simple graphical method such as described in the accompanying diagram will be found very useful.

The maximum current which should flow on the first



Use of a diagram like this will simplify the work of calculating the starting resistance for d. c. motors.

step of the starter should be only sufficient to start the motor. If the starting current is over 20 amp., the first step should allow 20 amp. to flow, the second 40 amp. and so on until the motor starts. Thereafter, the back emf. of the machine gradually increases and the necessary series resistance is decreased. A gradual

cutting out of starting resistance is required to attain perfectly uniform acceleration. This is possible with liquid starters, but with wire rheostats, the number of contacts is limited between the range of 6 to 12 for small and medium sizes. The resistance between each contact is chosen so that on moving from one contact to the next one, the current does not rise above a predetermined limit, depending upon the design and construction of the motor.

The armature resistance Ra can always be measured according to Ohm's law, $I = E \div R$. Substituting the maximum allowable current for starting Im for I, one can compute the total resistance R of the circuit, which is equal to the armature resistance Ra plus the rheostat resistance Rt. The total amount of resistance necessary in the rheostat will be $Rt = R - Ra$.

The graphical layout is made as follows: Ra and Rt are measured according to a convenient scale on the horizontal axis KO, Im and Io, the maximum and minimum allowable starting current respectively, are represented similarly on the vertical axis. The current which would have to be uniformly maintained to get the desired uniform acceleration would be $(Im + Io) \div 2$. Draw the rectangles $KODC$ and $CDBA$ as shown. Draw the diagonal OA, and from the point of intersection E on line CD, drop EF perpendicular to AB. Draw line OF and from the intersection point G drop GH perpendicular to AB, and so on. The perpendiculars extended in each case intersect line KO and give the amount of resistance, R_1, R_2, R_3, R_4, that should be inserted between starter contacts. *1* and *2*, *2* and *3*, *3* and *4*, and so on, according to the scale previously chosen. These values are also proportional to the time that the rheostat arm should be held on the respective contacts. The potential difference between adjacent contacts should never exceed 30 to 35 volts.

Bressoux, Liege, Belgium. PIERRE VAN HERK.

MOTOR WINDING

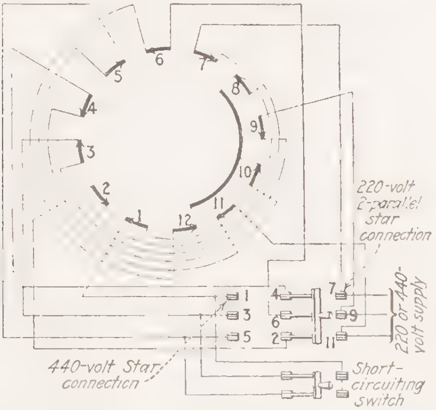
How to Connect Motor for Use on 220 or 440 Volts

In plants where 220 and 440 volts are used, spare motors might have to be cut over in a hurry from one voltage to the other and a great deal of time lost by reconnecting. There is also the possibility of rented motors or portable sets having to be reconnected to suit the voltage.

The winding of a three-phase, four-pole motor can be arranged for quickly changing the connection from single star to two-parallel star or *vice versa*, by bringing out nine leads and connecting them to a three-pole, double-throw, knife-switch, as shown in the diagram. By throwing the switch to the left, a single-star con-

nection is formed, for use on 440 volts. With the switch thrown to the right, the winding is connected two-parallel-star for 220 volts. When the switch is in this position, terminals *1*, *3* and *5* must be shorted by a double-pole, single-throw switch to form the other star point.

This method can be applied to either a four- or six-pole winding. When connected for six poles, the groups must be laid out and numbered in the same way as for four poles, only there will be 18 groups instead of 12,



For a four-pole motor, nine leads are brought out from the stator winding and connected as shown. By throwing the three-pole reversing switch to the left a 440-volt, single-star connection is obtained. When leads *1*, *3* and *5* are short-circuited and the reversing switch is thrown to the right, a 220-volt two-parallel star connection is made.

as in a four-pole connection. Consequently there will be more jumpers, but there will be 12 leads from 12 consecutive groups; the first six will be starting leads and the last six will be finishing leads. It makes no difference which leads you count as the same connection is obtained. Out of 12 leads, Nos. *8*, *10* and *12* form the star, and should be connected inside of the motor. This is done also in the four-pole connection in the diagram.

Los Angeles, Calif. HENRY KAELIN.

Chart for Determining Speed or Number of Poles in Motor

When making speed changes, and on other occasions, it is often necessary to determine the speed or number of poles in which the stator of an induction motor is wound.

MOTOR SPEED CHART

To determine speed of motor place straight-edge on number of poles and on center of cross and read speed on right-hand column. For number of poles, place straight-edge on synchronous speed and center of cross and read number of poles on left-hand column.

If the frequency and either the speed or number of poles are known the other value may be found by means of the accompanying chart, which was drawn up to

show the relation between the number of poles and the synchronous speed of induction motors operating at 25 and 60 cycles.

This chart is based on the formulas, $P = (120 \times F) \div$ r.p.m., and r.p.m., $= (120 \times F) \div P$, in which P equals number of poles, F is the frequency and r.p.m. represents the revolutions per minute.

When using the formula first given to determine the number of poles, the synchronous speed should be taken. The full-load speed must not be used, as it will not give a whole number of poles.

When using the chart to determine the number of poles, place a ruler or straight-edge on the synchronous speed shown in the left-hand column and on the center of the cross, and read the number of poles that is indicated in the right-hand column.

Should it be desired to find the speed with a given number of poles, place the ruler on the figure representing the number of poles and on the center of the cross and read the speed on the left-hand column.

Rock Springs, Wyo. CHAS. F. CAMERON.

Drum Controller for Slip-Ring Motor Rearranged for Squirrel-Cage Motor

In making some changes at our plant it was necessary to install a squirrel-cage motor for which we did not have a controller or starter. In looking through our spare equipment a drum controller for a wound-rotor, induction motor, was found, which we thought would be suitable, provided we could change it from the secondary-resistance type to the primary-resistance type. The manner in which this was done is interesting.

Fig. 1 in the accompanying diagram shows the arrangement of the original controller, with three sections *a*, *b*, *c* of the short-circuiting segments; these sections are cast in two halves and split vertically. In changing the controller we arranged it as shown in Fig. 2. It will be seen that section *c* has been removed and sections *a* and *b* separated by cutting the casting. Sections *a* and *b* are insulated from each other by mica or fiber washers and connected to the reversing segments by the leads *m* and *n*, as shown.

This arrangement put the resistance in the stator side of the motor circuit and thus made the controller suitable for primary-resistance starting of the squirrel-cage motor. It will be noticed that line L_1 in Fig. 2 is not opened with the controller in the "off" position; therefore, the motor has one line lead always connected to the supply. A line switch should be provided to disconnect the power supply from the controller, or two additional segments and fingers could be added to the controller so that line L_1 could be disconnected when the controller is in the "off" position.

New Westminster, B. C., Can. W. L. STEVENS.

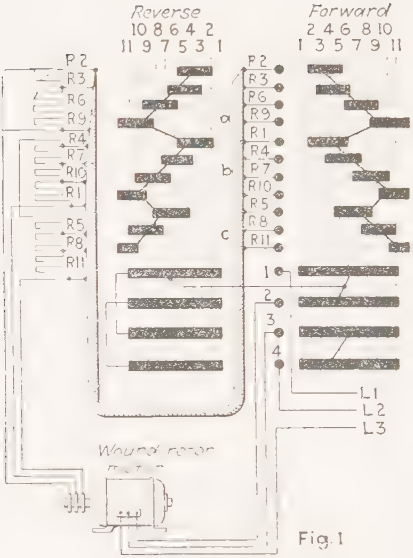


Fig. 1

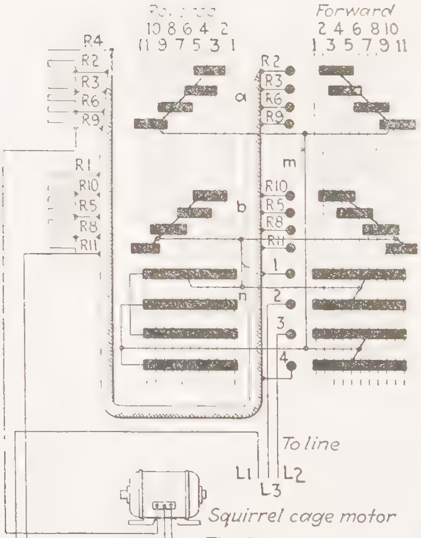


Fig. 2

The connections of the controller were changed as shown below.

Fig. 1 shows the original connections of the controller. For use with a squirrel-cage motor, the connections were altered as indicated in Fig. 2.

WELDING

Use of Welding in Resurfacing Wearing Parts to Resist Abrasion

Abrasion is one of the most serious problems for industrial operating and maintenance executives in many industries. This is particularly true in such industries as cement manufacturing, where metal parts of pulverizing, grinding, crushing and conveying machinery are worn out in a short time through abrasion. In a paper presented before the New York Section of the American Welding Society, A. V. Harris, Haynes Stellite Co., New York N. Y., gave some interesting details of the results obtained by several plants in this industry that have successfully tried welding a coating of Stellite on the welding surface.

Stellite is not a steel, but an alloy of cobalt, chromium and tungsten, and is produced in an electric furnace. It is a hard metal that resists abrasion, heat and corrosion, requires no tempering, and is cast to form; it can be finished only by grinding. This metal is widely used in cutting tools for machining metal.

Recently, however, considerable attention has been given the use of Stellite for surfacing in maintenance work, and a number of practical applications have been made of depositing it, by means of welding equipment, on a surface subject to abrasion. It is said that it can be applied without heat treatment to copper and to any grade of steel, including carbon and alloy steels, and to practically any cast-iron surface.

For this coating or Stelliting, as the process is called, the alloy is provided in the form of welding rods. The surfacing, however, calls for a slightly different technique than most acetylene welding in that the process is neither welding nor brazing in the ordinary sense of these terms. For example, when welding, the surface of the base metal is brought up to the flowing point and the Stellite welding rod is then puddled and fused with the molten base metal.

Stelliting calls for blowpipe flames that contain a fairly large excess of acetylene to lower the flame heat and to exclude as much atmospheric oxygen as possible. The surface of the base metal to which the Stellite is to be applied is brought up to such a heat that it just begins to sweat and assumes an oily appearance. The lightest possible penetration into the parent metal is most desirable, since this eliminates the possibility of an undesirable alloy being formed with the Stellite.

At this point the Stellite is melted from the rod and allowed to flow on to the base metal with as little agitation as possible. The action when flowing on to the steel is similar to that of solder flowing from an iron on to a tinned surface. Examination of a Stellite weld made in this manner shows that practically no penetration into or alloying with the base metal has oc-

curred. This coating may also be applied with the electric carbon or metallic arch process, it is stated.

Stellited metal parts, when used in pulverizing, grinding, crushing and conveying machinery in the portland cement industry, have a greatly increased life. A screw conveyor of the conventional type when coated on the periphery has, it is said, lasted six times as long as a heat-treated carbon-steel screw. A special surface ⅛ in. thick on a gudgeon as used in the cement plant will give that part a life three times as long as ½ in. of steel.

Hot drag chain supports, conveyor buckets and cams, steam shovel dipper teeth and roll mill plows may also have their life increased by thus coating the wearing surface. The combination properties of resistance to heat and resistance to abrasion are utilized in hot-drawing and hot-forming dies with an increase of three to five times in their life. The die is called upon to resist the heat of the metal that is being formed and the abrasion of this metal as it is drawn.

In the manufacture of dry cells or dry radio batteries a number of dies and machine parts come in contact with active chemical compounds that tend to corrode and destroy the metals used. Their life by coating may be increased because of the ability of this alloy to resist corrosion as well as abrasion.

Reinforcing Welded Joints to Increase Strength

Unless the work has been very carefully done, a weld in heavily stressed parts is likely to be of less strength than was the original material. To compensate for this diminution in strength of the broken part, in addition to amply filling around the joint, some method of reinforcing the welded joint is often adopted.

To reinforce a break in a solid bar, a sleeve may be placed over the break and welded at both ends. This method is employed where the joint in the rod is stressed by either a pull or by a bending force.

An inner sleeve may be used in tubing, to reinforce a welded joint. This method of repair will suffice where the joint is subjected to either a bending or a tensile stress.

Plate welds which are as strong as the plate are difficult to make. The best way of making a very strong joint is to use butt straps. Holes are punched in the strap and the welding is done both at the break and at the holes in the reinforcing straps. When properly made, such a joint is very satisfactory and makes a continuous weld across the plate unnecessary.

These methods of reinforcing welds not only represent years of study by a large plant specializing in shop and ship repairs, but they have proved their effectiveness, for some of the joints have been tested under actual working conditions in the same plant where they were made.

GEORGE A. LUERS.

Washington, D. C.

Advantages of Replacing Broken Castings With Welded Steel Parts

Broken castings frequently require a long time to replace, whereas the broken part may, in many cases, be reproduced in welded steel construction within a few hours and at a fraction of the cost of a new casting.

Standard steel plate, tube, rounds, bar stock and structural shapes are cut as required and the assembly made by electric arc welding. Practically any casting may be reproduced by this method. The welding operator either works from dimensions taken from the broken casting itself or, in case modifications are to be made, from a pencil sketch. Any steel warehouse can supply all of the parts required, cut to size and ready to assemble in a short time. In the machining operations, the welded steel piece is treated in the same manner as though it were a rough casting.

Operating men who have become familiar with the practice of making the welded steel equivalent to castings in many cases overcome defects of design in making the new parts. As steel is four or five times as strong in tension as cast iron, and two and one-half times as rigid, it is a better material for machine parts than is cast iron. Taking this superiority of steel into consideration and making slight changes in shape has in some instances eliminated trouble of long standing. Steel parts will seldom break—the worst that will happen is that the steel part will be bent out of shape by unusual stresses, in which case it may be restored to usefulness by straightening.

On account of the unbreakable feature of welded steel parts, together with their lower cost as compared with castings, an increasing number of machines are being built of steel instead of castings. This renders obsolete some machines that were formerly built of castings, so that for all practical purposes making spare parts of welded steel is the only method of repair.

In case a plant is not already equipped with an electric arc welder, welded steel parts can be made in any commercial welding shop that is properly equipped.

Chief Engineer,
Welder Division,
The Lincoln Electric Co.,
Cleveland, Ohio.

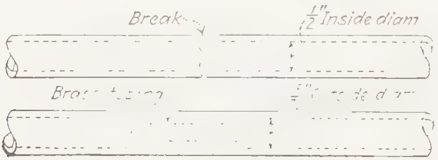
ROBT. E. KINKEAD.

Reinforcing Light Metal Tubing Before Welding

Among the miscellaneous repair jobs which the industrial maintenance department is frequently called upon to handle, is the welding of broken steel and brass tubing. This is a troublesome job because the walls of the tubing are very light and melt quickly under the heat of the welding equipment. The result is an

ever-enlarging hole. A method of overcoming this, as recommended by The Linde Air Products Co., New York City, is shown in the accompanying sketch.

In this instance, when welding a piece of tubing ½ in. inside diameter, a short length of 15/32-in. tubing, outside diameter is slipped inside of it. This makes an inside sleeve which provides a backing for the weld. If acetylene welding is used, it is recommended that a



Using an inside sleeve enables the operator to weld light tubing without burning the metal.

⅛-in. bronze rod and a small flame with little heat should be employed on steel tubing, as the metal is thin. If the tubing is of brass, a ⅛-in. brass welding rod is recommended.

Savings Made in Repairing Water Wheel Casing by Arc Welding

An electric arc welding operation that was recently performed on a water wheel saved the company involved approximately $800 and the job was completed in 11 weeks' less time than would have been the case if it had been necessary to wait for a new section of the casing.

This water wheel casing was badly in need of repair, for the bearing had become worn, thus allowing the wheel to move over and wear away a section of the casing. The worn section was about 10 in. wide by ¾ in. to 1 in. deep around the entire periphery of the casing. In some spots the casing was worn away entirely and in others the parent metal was only 1/32 in. thick. Some holes up to 1 ft. long had previously been covered by a patch on the outside.

A Westinghouse 200-amp., three-phase, 25-cycle, 550-volt, portable arc welding set was used on this job. The very thin section and the part that was entirely worn away were first spanned by circular hoops made of steel rods. The first rod, ⅝ in. in diameter, was welded to the neck of the casing, another ⅝-in. rod was welded to this one and a ¾-in. rod was welded to the second rod, a space being left between this third rod and the next one large enough to insert a ⅝-in. rod. After a ½-in. rod was welded to the cast-iron casing, the ⅝-in. rod was inserted in the place left vacant for it, and welded to the rod on each side of it, thus bridging over the weakest part of the casing. The rest

of the worn section was then filled in and the surface of the casing ground to a smooth finish by means of a portable grinder.

The striking feature of this job is that is was completed at a cost of approximately $200 and in seven days' time, whereas a new casing would have cost $1,000, and could not have been obtained for at least three months.

WIRES

Inspection of Electric Elevator Cables

The condition of an electric elevator cable may often be revealed by a simple inspection; that is, by going slowly over the entire length of the cable carefully looking for worn places. Such inspections will occasionally reveal one or more defective conductors beneath the surface, which may be broken or partly broken. If it is desired to make periodical tests to determine the condition of a cable before trouble develops, the following method is a good one to follow:

On one end of the cable being inspected connect together all the conductors in the cable with one common wire, which should also be grounded to a water pipe or some other suitable ground. Next, connect a battery of several volts in series with a set of head phones, volt-meter, or whatever instrument is to be used for testing. Then connect one end of the test set to the ground and the other end to a feeler wire.

With the feeler wire touch each wire at the opposite end of the cable. As each conductor is touched, a deflection of the voltmeter, or a click in the phones, if phones are used, will be obtained when the conductor under test is continuous. But if there is a total break in one of the conductors, generally no deflection of the voltmeter, or click in the phones, will be obtained. The exception in some cases is due to the fact that the phones will click even though there is a break in a conductor, providing the circuit has sufficient capacity.

To find partial breaks follow the same procedure of testing, but after connections have been made, twist the cable back and forth slowly throughout its entire length, and if a partial break exists, the voltmeter will give an unsteady deflection.

ARCHIE L. FORGER.

Chief Electrician,
The G. A. Head Electric Co.,
Laconia, N. H.

Factors That Affect Safe Current Carrying Capacity of Copper Wire

The proper size of wire to use for any current value is decided after consideration of at least one of three factors. These three factors are: the voltage drop in

the wire, the value of the power lost in the wire, and the temperature rise because of this power loss. The first two of these items will vary directly as the resistance of the wire, but temperature rise depends not only upon the resistance, but also upon the ability of the wire to dissipate the heat that is generated within it.

The resistance of two wires, if they are made from metal of the same specific conductivity will vary inversely as their cross-section area. However, the ability to radiate heat will depend to a great extent upon the surface area which will vary as the circumference for wires of the same length. The cross-section area of wire will vary as the square of its diameter, while the circumference varies directly with the diameter. Therefore, the radiating surface does not increase nearly as fast as the cross-section area and for this reason large wires cannot carry the same ratio of current in proportion to their circ. mil area as smaller ones.

An example of this decrease in the safe current carrying capacity as the wires become larger may be found in a table prepared by the National Board of Fire Underwriters. According to this table, No. 14 wire with an area of 4,000 circ. mils has a carrying capacity of 15 amp. for rubber insulation, 18 amp. for varnished cloth and 20 amp. for all other insulation. This gives an average between 4 and 5 amp. per 1,000 circ. mils. For a wire area of 2,000,000 circ. mils, the carrying capacity averages around 1,300 amp., or has decreased to less than ¾ amp. per 1,000 circ. mil for the different insulated wires of this size.

Many electricians judge the safe-current-carrying capacity of a cable by the current density, that is, the number of amperes per 1,000 or per 1,000,000 circ. mils. As may be seen from the example given above, this is poor practice, since the safe current density decreases with the size of the wire.

G. H. McKelway.

Westfield, New Jersey.

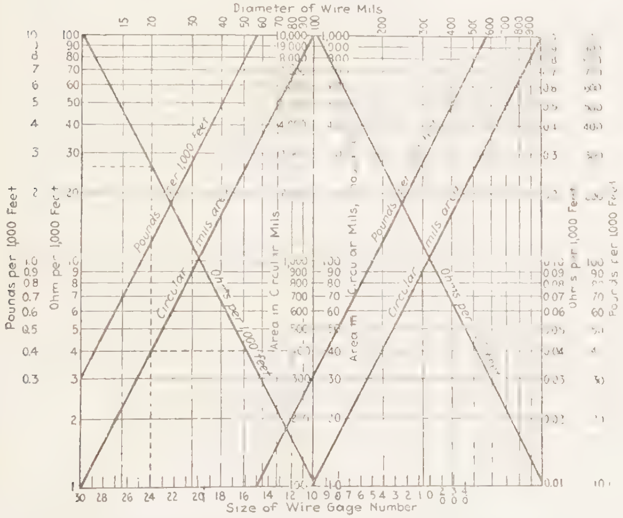
Chart for Finding Physical Properties of Copper Wire

The accompanying copper wire chart illustrates the wire tables graphically and the regularity of the sizes of wire shows that the tables were designed with a uniform variation when referred to a logarithmic scale. It will be noted that the sizes of wire given in the gauge numbers are spaced evenly. The difference between the diameters of No. 29 and No. 30 wire is 1.3 mils, while the difference between the diameters of No. 3/0 and No. 4/0 wire is 50 mils. The reason for the difference in the increment or decrement is that, for all practical purposes, wire with a diameter of 459 mils would serve as well as a wire with a diameter of 460 mils.

It was then decided to make the wire tables with a constant ratio between the areas. This was not a needless complication, but rather a simplification. The user

of the American Wire Gauge is fortunate because it is the only system that has any scheme of regularity and adheres strictly to that scheme. The three straight lines on each side of the accompanying chart demonstrate conclusively that in the American Wire Gauge there is a constant ratio between the area, resistance and weight of one gauge number compared with that of another.

To use the chart, trace vertically upward above the desired size of wire to the intersection of that line and the diagonal line marked *Circular Mils Area* and from this intersection trace horizontally to the column with



The cross-sectional area, weight and resistance of No. 30 to No. 4/0 copper wire can readily be determined from this chart.

In order to determine the area, weight or resistance of a certain size of copper wire, trace upward from the gauge number of a certain size of wire to diagonal line marked *pounds per 1,000 ft., circular mils area, or ohms per 1,000 ft.,* as the case may be, and from the intersection between the line drawn vertically and one of the diagonal lines trace horizontally to the column marked the same as the diagonal that has been intersected by the vertical line.

the same marking where the area in circular mils is indicated. To find the pounds per 1,000 ft. continue the vertical tracing until the diagonal line marked *Pounds per 1,000 ft.* is met and read the value given by the horizontal projection in the column marked *Pounds per 1,000 ft.* The ohms per 1,000 ft. is found in the same manner.

An example will illustrate the above procedure and also demonstrate what degree of accuracy may be expected. Suppose for instance it is desired to find the

area, weight and resistance of No. 24 wire. To find the area of the wire, start from the point at the bottom of the chart marked No. 24 gauge and trace the dotted line which extends upward in a direction vertical with the bottom of the chart to the diagonal line marked *Circular Mils Area*. From the intersection of these two lines trace horizontally to the column marked *Circular Mils Area* to find area of No. 24 gauge wire. By continuing to trace the dotted line upward until it intersects with the diagonal line marked *Pounds per 1,000 ft.*, and further on to the diagonal line marked *Ohms per 1,000 ft.*, the weight and resistance of the wire may be found.

On the parts of the chart marked with the larger graduations, it is evident that the values may be read to the second significant figure, the third being estimated. With the finer graduations, it is necessary to estimate the second significant figure. After a small amount of practice, the chart may be used with confidence and with the knowledge that the figures obtained are only slightly in error.

C. F. CAMERON.

Rock Springs, Wyo.

Heating Caused by Carrying Each Phase of 3-Phase Circuit in Separate Conduit

Current for the various "sets" in a large moving picture studio was delivered from the three-phase transformers to the switchboard buses at 110 volts. Four 500,000 circ. mil cables for each of the three phases served as the jumpers connecting the transformers and buses; each phase, comprising four cables, was carried in a separate conduit.

When a large number of the sets were being used these conduits became very hot, thus threatening deterioration of the insulation. At no time did the cables themselves carry capacity load, as was shown by checking the load with an ammeter.

Heating of the conduit was assumed to be due to the eddy currents induced in it by the single-phase currents carried by the four jumper cables. That this assumption of the cause was correct is evidenced by the fact that later when extensions were made to the plant and the switchboard buses were revamped, the jumper cables were reconnected so that each conduit carried three-phase current instead of single-phase.

As there were then four cables in each conduit to carry the necessary current and it was desired to use these, besides saving the labor of pulling out the four old ones and pulling in three new cables of the same or slightly greater current-carrying capacity, an extra single-phase cable was left in each of the three conduits.

After reconnecting to the buses, there was still an unbalance of single-phase current in each conduit, but this unbalance was only one-fourth of what it was

originally when there were four single-phase cables per conduit. Under the new conditions the conduit hardly heated enough to be noticeable, with the "sets" all pulling full load.

S. H. SAMUELS.

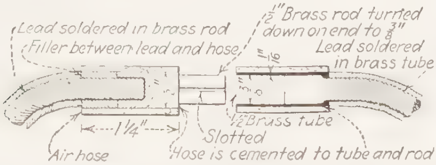
Oakland, Calif.

How to Make Portable Power Connector for Hard Service

After trying several makes of power connectors and finding none that would stand the weather and abuse around a strip mine, I designed the one shown in the accompanying illustration.

As will be seen, this connector consists of a male and female portion, each of which is protected by a piece of ½-in. air hose. The male end is made from a piece of ½-in. brass rod which is drilled out at one end to receive the conductor. The other end of the rod is turned down to a diameter of ⅜ in. and slotted as shown. After slotting this part it is advisable to spread it slightly so that it will make better contact and be held more firmly in place.

The female end of the connector is made of a piece of ½-in. brass tube with an inside diameter of ⅜ in.



Here is a portable power connector that is easy to make and has proved very satisfactory in service under severe conditions.

The lead is soldered in the brass tube, leaving a sufficient length of the tube open to receive the male portion. The pieces of air hose, which should be about 1¼ in. long, should be cemented in place over the tube and the rod. One important advantage of the hose is that it does not warp when it becomes wet, and will stand more abuse than a fiber handle or sleeve.

This power connector has proved entirely satisfactory in service and will be found very useful wherever portable cords are used under severe conditions.

R. C. VORDERSTRASSE.

Chief Electrician,
United Electric Coal Co.,
Lewiston, Ill.

INDEX TO
PLANT ENGINEER'S MANUAL

I. AROUND THE PLANT

SYSTEMS

PAGE

Inspection System Forestalls Production Delays at Dennison Mfg. Co. 9
Handy System for Keeping Service Records of all Machines in Plant 12
Method of Checking Work on Large Installations 14
Routine for Lubrication and Inspection of Cranes 15

SAFETY

Construction of Rungs and Safety Ring for Ladder on Brick Wall 16
Safety Rules for Guidance of Crane Operators. 17
First Aid for Eye Injuries 18
Safety Lock on Pedal-Operated Machine 20

HANDY PLANT KINKS

Portable Motor Unit for Emergency Service... 21
Chain Conveyor Protected from Paint in Spray Booth 22
Scraper for Cleaning Shafts 22
Bench Truck for Transporting or Repairing Motors 24
Handy Shelves for Shop Purposes 25
Changing Method of Driving Exhaust Fan Solved Motor Trouble 26
One Way to Obtain Constant Spray Density... 28
Anchor Bolts Lengthened by Bushing Method.. 29
Portable Gage for Determining Depth of Water in Wells 30
Supporting Motor Overhead in Sawtooth Construction 31
Checking Alignment for Bridge on Traveling Crane 32
Protecting Wire or Hose Lines Lying on Floor. 35
Changing Electric Light Fixtures Saves $25.05 on Each 35
Channel Iron Used in Making Sliding Base for Motor 36
Portable Floodlight Made for $4.18 37
Grounding Machines to Prevent Static Discharges 38
Truck for Acetylene Outfit is Easily Constructed 39

II. MECHANICAL

BELTS

PAGE

Fasteners to Fabric Base Belts, Suggestions on the Application of 43
Driving Adjustable Spindle from Fixed-Position Motor 44
Rubber Belting, Suggestions on Care of....... 45
Alignment Chart Determines Width of Belts... 46
Applying Belt Dressings, Recommendations for. 47
Chart for Determining Arc of Contact on Belt Drives 48
Chart for Determining Belt Speed............. 49
Pulley for Fabric-Base Belts, Determining Size of 51

BEARINGS

Precautions to Take When Using White Metal for Rebabbitting Bearings.................. 53
Babbitting in Bearing Seats for Ball or Roller Bearings 54
Precautions to Take When Installing Ball or Roller Hanger Bearings................... 56
Oxyacetylene Torch Used for Relining Bearings 58
Improper Use of Thrust Ball Bearings on Worm Causes Trouble 59
Selecting Proper Babbitt for Armature Bearings 60
Using Chart to Determine Horsepower Loss from Friction in a Bearing................. 61
Precautions When Rebabbiting Bearings 63

LINESHAFTS

Mounting Countershaft to Allow Easy Adjustment 65
Emergency Bracket for Mounting Lineshaft on Pit Wall 67
Supporting Double Row of Shafts from Building Column 68
Supporting Lineshafts in Mill-Type Building on Standard Angle-Iron Ground Work.......... 70
Method of Welding Up Steel Post Bracket for Pillow Block 71
Gage for Aligning Shafts Easily Constructed.. 72
Checking Parallel Alignment of Machines with the Lineshaft 73
Water Gage for Leveling Lineshafts 74
How to Remove Frozen Shaft by Use of Oxygen Lance 76
Repairing Worn Shaft Under Loose Clutch Pulley 77
Simple Device for Removing Pinions or Pulleys from a Shaft.............................. 78
Where and Why Lineshafts Break in Service... 80
Wedges for Driving Pinion from Shaft......... 81
Aligning Parallel Shafts 82

LUBRICATION

Lubrication Insured by Control Devices and Warning Signal 83
Oil Rings for Emergency and Permanent Installation 84

PAGE

Changing Method of Feed Solved Lubrication Problem ... 84
Handy Oil Well Cover Permits Easy Access to Bearing ... 85
Lubrication of Ball Bearings, Recommendations for ... 86

MECHANICAL POWER TRANSMISSION

Increasing Pulley Diameters Made Drive Pull Load ... 88
Overcoming Shock and Moisture on Board Mill Drive ... 89
Connecting-Up Silent Chain to Engine Shaft to Drive Reciprocating Pumps ... 90
Installation Error in Alignment, Couplings Used to Compensate for ... 91
Pulley Wear Due to Slip of Dusty Belt Prevented by Short Center Drive ... 92
Obtaining Half-Speed Drive for Special Work .. 93
Substituting Long-center Chain Drive for Bevel Gears and Shaft ... 94
Emergency Speed Reducer Built from Auto Steering Gear ... 95
Driving Double-Purpose Blower at two Speeds. 96
Variable-Speed Transmission Versus Variable-Speed Motor ... 97
Driving Two Shafts from One Motor ... 99
Repairing Worn Flange on Pinion of Chain Drive ... 100
Estimating Horsepower Transmitted by Line-shafting ... 101
Chart for Determining Power Transmitted by Friction Wheels ... 103
Safe Method of Lining Transmission Guards while Operating ... 105
Flexible Drive Solves Fan Operating Problem .. 107
Selecting Worm Gear Speed Reducers of Proper Capacity ... 108
Breaking Pins Protect Drives Against Overloads ... 113
Quieting Noisy Gears, Simple Methods of ... 116
Decreasing Pulley Wear from Abrasive Dust on Belts ... 118
Refacing Surface of Fiber Pulley ... 118
Roller Chain Used on Quarter-Turn Drive ... 119

III. ELECTRICAL

BATTERIES

Cleaning Dirty Storage Battery Boxes, Proper Method of ... 123
Automatic Charging Station for Storage Battery Trucks ... 123

DRYING OUT COILS

Drying Out Water-Soaked Generator Coils ... 125
Drying Out Shunt Field Coils ... 126

ELECTRIC CONTROLS

PAGE

Power Output Increased by Reconnecting Transformers....127
Stopping Motor When Pump Loses Suction....128
Changing Overload Protection to Meet Service Demands....129
Supporting Graphic Meters to Overcome Vibration....130
Protecting Heater Units When Blower Belt Breaks....130
Cutting Meter Into Circuit....131
Voltage Records Used to Select Proper Lamps..132
Stopping Motor When Conveyor Clogs, Control for....134
Potentiometer to Supply Power for Signal Systems, Use of....135
Effects of Overvoltage on Contactor Coils Reduced by Using Reactors....139
Flashlight Used for Testing Fuses....140
Limit Switch to Prevent Overtravel of Hoist...141
Connecting Auto-Transformers for Lighting Circuits....143
Saving Made by Eliminating Lightly Loaded Transformer Bank....144
Interlocking Control System for Overhead Tramways....146
Facts to Remember About Care of Renewable Fuses....148
Fuse Puller, Durable and Inexpensive....150
Interlocking of Screen Motor Control Prevents Damage from Overflow....150

ELECTRIC TESTING

Accuracy of Watt-Hour Meters, How to Determine....152
Power Factor with Slide Rule, How to Determine....153
Rheostat for Testing Fields of D. C. Motors and Generators, How to Make....155
Checking Up and Servicing Electrical Troubles.156
Power Factor with Watt-Hour Meters, Determining....157
Ground Detectors for Use on Low-Voltage Systems....160
Resistance of Ground Connections, Determining.165
Testing Equipment for Fuses and Lamps....168

HEATING OVENS

Preheating Fuel Oil Electrically....170

INSULATION

Insulation Resistance and Dielectric Strength, Comparison of....171
Testing Insulation Resistance of Electrical Equipment....174

LIGHTING

Chart for Determining Lighting Requirements..177
Warning Lights on Crossing Gates Controlled.178
Relay for Lighting Lamp when Telephone Rings.179

MOTOR REPAIR

PAGE

D. C. Motor Troubles, Causes and Remedies for Some 180

Induction Motor Noises, Causes and Remedy of....182

Care of Mica Segments in Commutators....183

Cleaning Motors, Methods of....184

Mixture for Protecting Commutator V-Ring Insulation from Oil....184

MOTOR TESTING

Ammeter Indicates Single Phase Operation of Motors....184

Graphic Method for Determining Power Output of Induction Motors....185

Graphic Method of Computing Starting Resistance for D. C. Motors....187

MOTOR WINDING

How to Connect Motor for Use on 220 or 440 Volts....188

Chart for Determining Speed or Number of Poles in Motor....189

Drum Controller for Slip-Ring Motor Rearranged for Squirrel-Cage Motor....191

WELDING

Use of Welding in Resurfacing Wearing Parts to Resist Abrasion....193

Reinforcing Welded Joints to Increase Strength....194

Replacing Broken Castings with Welded Steel Parts, Advantages of....195

Reinforcing Light Metal Tubing Before Welding....195

Savings Made in Repairing Water Wheel Casing by Arc Welding....196

WIRES

Inspection of Electric Elevator Cables....197

Factors That Affect Safe Current Carrying Capacity of Copper Wire....197

Chart for Finding Physical Properties of Copper Wire....198

Heating Caused by Carrying Each Phase of 3-Phase Circuit in Separate Conduit....200

How to Make Portable Power Connector for Hard Service....201